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THE INTERIOR OF THE EARTH.

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BY

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INTRODUCTION.

THE subject of these few pages is one that has from all time been of interest and instruction to the human race. Our Bible teaches it; philosophy writes of it; theories of many sorts have been issued regarding it; and the literature of the present day is constantly occupied with its details. I have selected a few authors to whose opinions and theories I cannot consent. I give my reasons, and state the system as I believe in it from my own poor experience in natural phenomena. I have culled from contemporary literature such extracts as fit my subject; and though I may have employed them against the creeds of the authors, I am grateful to them for the instruction afforded by the perusal of their works. There is

no class of writers whose labours are more carefully conducted, but I believe the main point from which many of them start is founded in error, and hence has arisen the great difficulty in reconciling certain phenomena of the earth with nature. My intention is to offer a new interpretation of them, and I humbly hope the reader may find that it is a true one.

H. P. MALET.

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GEOLOGICAL THEORIES OF HEAT IN THE EARTH.

Introductory.

DID the Spirit of God move upon the face of the waters and create this earth, as the Bible tells us? or was it brought into its present condition from a molten liquidity, as some of our geologists tell us? In answering *these* questions, I propose to consider some of the latest theories which contemporary literature has placed before the world; and as these theories embrace several subjects which, though belonging to one great system, are called by various names, I shall devote a chapter to each, so that the theories of others on each particular point may be found with my objections. By this

method, I incur the risk of repetition; but when Nature is at work, this could scarcely be avoided in writing of varied effects of one great cause; and as each point is essential to the correct understanding of the whole, no definite answer can be given to my questions till the points alluded to have been discussed.

It is not my wish in this discussion to raise any questions of doubt or atheism, for I imagine that no one has ever written on this topic without a sincere conviction that he was right; and as the very nature of the subject necessarily leads to thoughts of one great Lawgiver and Creator, every writer must have felt that the gift of reason with which he delved into the mysteries of Nature was a gift from Him, and I have no doubt but that all have in their turn implored, as I now do implore, the assistance of God in reasoning rightly upon His wondrous works.

Gift of reason.

In venturing to doubt the correctness of some of the theories that have been placed before us, I do not intend to set myself up as a judge of the honesty of intention which dictated them. None of us have the same gifts; and the diversity of opinion on this subject, with the intensity of interest so

Varied.

frequently bestowed upon it, is sufficient proof of individual conviction. With this spirit in view, I would not wish that those whose gifts differ from mine should condemn my interpretations of natural conditions or phenomena without due deliberation; they vary from those interpretations lately accepted, but as yet our *philosophers* cannot determine which is right. I have, therefore, a humble hope that the gift of studying Nature has been implanted in me for some wise purpose. I have had opportunities which few have enjoyed, I have formed unbiassed conclusions from Nature, and having as I thought reached by my own endeavours the goal common to all, I now find in perusing the works of others, that there are goals of which I was ignorant. As there can be but one One truth. true goal, I offer my interpretations for the consideration of the public with the assurance that, as far as my poor gifts allow, I argue only for the truth. There may be found errors and oversights in my detail, but I hope to show, beyond a doubt, that this earth was created by the Spirit of God moving on the face of the waters.

With this brief introduction, I commence upon the subject with a few quotations from contempo-

rary writers. Nine years ago, we were told in that excellent compilation, "Advanced Text-Book—Geology" (Page), p. 24: "We have no certain evidence, geologically speaking, of the earth ever having been in a molten or semi-fluid condition." This author has, however, a leaning to this molten theory, and, since he wrote, the idea has taken such strong hold of geologists, that Mr. David Forbes tells us, in the *Chemical News*, of 23rd October, 1868: "There appears, however, to be almost perfect accordance amongst men of science in general, as to the hypothesis that the terrestrial globe was at one period in a state of molten liquidity." We might suppose that men of science would scarcely be content to accept this theory without trustworthy evidence, but Mr. Forbes continues: "The direct evidence afforded by the frequent and great outbursts of molten lava, ... lead to the very natural inference that these eruptions must proceed from some vast internal accumulation of molten matter." We shall presently see into what utter confusion this theory has advanced even in a few short months. However, we find another great authority using the same idea. Professor John Phillips tells us, in "Vesu-

Theories.

vius" (1869): "Beneath our feet, at a depth not too great to influence geological phenomena, the substance of the globe is fluid with heat" (p. 330). It will be seen by-and-by, that he has found occasion to allow a considerable licence to this fluidity, which will militate against the general fluidity here supposed; but while writing this, another authority has been put into my hand by a new weekly journal of science (*Nature*, of 2nd December, 1869), in which I find Dr. Stevenson Macadam, Chairman of the Royal Physical Society of Edinburgh, is reported to have said, with reference to geological changes: "The day has now gone by for either Plutonists, or firemen, or Neptunists, or watermen, to hold undisputed sway in the interpretation alike of ancient and modern changes; and the truth lies in the golden mean." While this Theories. gentleman approaches so close to the truth, and uses language which I shall refer to again, I will enter his own theory of the changes here alluded to. He "believed that the spheroidal theory of the earth's crust . . . . with the doctrine of the correlation of the physical forces, was sufficient to account for all volcanic phenomena." These forces are explained, that as "physical magnetism and electricity can

become heat, there seems no necessity for fancying the existence of reservoirs of molten matter waiting for ages to be discharged through the crust, or regions of uncombined elements longing for water to quench their thirst." This authority calls the molten matter a fancy; and though I cannot consent to his own theory of magnetism and electricity, I quite coincide with him that the molten liquidity exists only in fancy. But we must go on with the history to enable others to judge of our correctness.

In my own little book, "The Circle of Light, or Dhawalegeri" (Newby, 1869), p. 209, may be found, "Fire has in its place and in its turn contributed to a re-creation."

Taken altogether, these quotations form as fine a medley as one would wish to meet with. We shall, as we go on, see how the arguments support the theories of evidence brought forward by Mr. David Forbes. There is an assumed heat within the earth, known chiefly, as Page tells us, "on the ground of increasing temperature as we descend;" so that at about 25 miles below the surface the heat is sufficient to fuse many of the rocks which compose the crust of this earth, that

the cooling process is still going on, and contracts the crust, and this contraction, "even to the fraction of an inch, would be sufficient to squirt out molten matter from a hundred pores or craters." On this I can only afford to remark, that if there is a liquid mass always ready within the earth, and if this liquid mass is at any time liable to a pressure from rocky substances when they cool, that this pressure must be perpetually at work, so that a squirting out having once commenced, I am at a loss to account for its cessation. Page, however, goes on to say, at p. 177: "The molten mass will obey the law of hydrostatic pressure, and be propelled to whatever craters or fissures may already exist." Of course it would if this was the principle of the emission of molten matter; but Page forgot the closed-up craters of Auvergne, of Iceland, and many other regions. As the molten lava no longer issues from them, it follows that either there is no pressure, or no molten matter; quite possibly none of either.

Inquiry into.

Page gives us an objection to this mechanical theory on the ground that, if all the supposed igneous rocks proceed from a common source, "there ought to be a greater uniformity among

Mechanical process.

them;" but he overrules this sensible remark by saying, that the "cooling, fusion, refusion, and comminglement with the molten matter of the stratified rocks, through which the eruptions took place," account for the varied condition of the emissions. This must be pure fancy, or Page, with his usual accuracy, would have told us the nature of the unmingled molten mass—how much of the exterior emission was due to that, and how much to the accidental mixtures. One thing, however, is to be gleaned from this sentence, which will be applied presently, viz., the eruption of molten matter would melt the rocks in passing!

Supposing, however, that there is one great internal reservoir of liquid matter beneath our feet at a depth of some 20 or 25 miles, how is this brought up to the surface? Page tells us, by contraction; but Mr. David Forbes (*Athenæum*, April 3, 1869) says: "I am certainly not prepared to attribute the issuing of molten matter from our volcanoes solely to this cause." He does not say what other cause assists the great delivery, but, forgetting the doctrine which I have quoted above, he refers me (his correspondent in the *Athenæum*) to "Vesuvius," thus endorsing the

following extraordinary solution of the problem. At p. 331-2, I find that the liquid matter may be in separate "basins, as under separate volcanoes, so confined within solids as to compel them to yield as a mass in sympathy with the solid crust. Such a state of things is in no degree unlikely, and at least leaves the geologist quite free to adopt any suitable depth for lava without fear of the mathematician." Here, then, we have small localities of any depth containing a molten material liable to be affected by the great general supposed contraction of the earth's crust. How in this case could the theory of Mr. Forbes be carried out, as he tells us in the *Chemical News* above quoted? "The liquid interior of the globe would be carried round along with it, the whole revolving together just as if the liquid had been congealed, and along with its retaining envelope actually formed one entirely solid body." Here, again, science puzzles me. If the liquid matter is in separate basins, how can it make one solid body with its envelope? and how could the little basins be liable to the universal contraction?

I will not insist on these discrepancies being fatal to the theory of either gentleman; but I have a

remark to make on the contracting principle. It has been argued that this force sends up matter to the surface from 800 miles, or 20, or 25. As the contraction is brought about by cooling, we must find out where this is supposed to begin. If rock is in a molten state at 20 miles of depth, and if, as "Vesuvius" tells us, water would boil by the supposed increasing heat within the earth at a depth of about two miles, we have 18 miles of hot rock left, and only two for it to become cool, cracked, and fissured, and, at the same time, to press upon the liquid mass with such force as to eject it up through 18 miles of its own earthy matter, which, if we believe those scientific authorities, must be in such a state of heat as to preclude the chance of fissure, crack, or dislocation, from contraction. There remains, then, the outside ring of about two miles. On the outside portion of this, the cold is felt in the frozen regions; and in the tropics and temperate zones, the heat of the sun is supposed to extend to 60 or 90 feet. At or about this depth, the earth is supposed to be as cool as it can be, for below this, from "experiments in coal pits, in artesian wells, and in metalliferous mines, a rise of one degree Fahrenheit's thermometer takes place for every 50 or 55 feet of

descent" (Page). At this rate, a degree of heat would soon be found, except in the frigid zones, which would give no contracting force to our rocks; and as we find this cooling ring, which must be the supposed contracting ring, at 100 feet in depth, and of only a few hundred feet in thickness, I appeal to miners, well-sinkers, and engineers in general to say how far a united contractile force could be found of that thickness and at that depth, furnished as it is with strata of every possible material—some soft, some hard, some permeable, some impermeable. Professor Phillips, in throwing a doubt over some theories of earth measurement, says, at p. 331, "Vesuvius," "Can anyone believe that lava is pressed up through channels of 600 or 800 miles?" I ask the same question of his 20 miles, but defer answering the question till other points have been discussed. Doubt.

So far, then, as the general principle of the application of mechanical power in the building of this earth goes, it appears to me that science has got into strange contradictions and difficulties. It may be that explanations may be offered; but so far as an examination of the first causes enable me to judge, there is no evidence whatever that even lava No molten accumulation.

outbursts are produced from any internal accumulation of molten matter.

Chemical process.

I will now shortly consider the chemical theory of volcanic action as given to us by science. It is the meeting of matter within the earth, resulting in combustion and explosion; or, as Page tells us (p. 118), when water comes in contact with "the metallic basis of the alkalies and earth, as potassiüm, sodium, calcium," they are decomposed with an evolution of intense heat, by which rocks may be fused, steam may be generated, and gases may escape. He allows the chemical principle to be more philosophical than the mechanical hypothesis; but he rejects it because our ignorance prevents our accepting it, "as adequate to account for the magnitude of the phenomena in question," and because "the greater extent of igneous action in earlier geological times would seem to point to a more stable and uniform source." Like many others, Mr. Page was enamoured of the mysterious internal fire system, or he would not have considered, as we shall presently see, that the interior of the earth was wanting in stability or uniformity; moreover, he rejects a cause, which is an ostensible one, for another which exists only in a "general

Rejected by science.

geological belief," without any certain geological evidence.

The chemical system, however, as placed before us by science, has scarcely a better foundation than the mechanical; for if the evidence of the making of this world depends upon the excitement of volcanic action from the meeting of alkalies and water at the depth of 20 or 25 miles, there is one point which is here deserving of remark. If, as Professor Phillips has told us, boiling water might be found some two miles below our feet, and if the heat of the interior progresses according to the scale above mentioned, I deny that any water or any steam could reach the region of supposed fused rocks, and there create a greater heat by their contact with the alkalies; so that, if the rocks depend upon this chemical process for their liquidity, at a depth of 25 miles, they must remain as they are, for all water and all steam would have evaporated long before they reached that depth. We shall see hereafter how, when, and where this chemical principle acts; but at present, science and geology have no escape from the conclusion—that the chemical theory of heat, in its present state, offers no evidence in favour of it as a world

The chemical theory as it is rejected.

creator; on the contrary, it is direct evidence that, if the cause of heat is local, there can be no universal heat.

Having thus used the writings of others to expose the fallacy of their principles, as well as the insecurity of their arguments, I propose going on in following chapters to show the truth of the sentence, "Fire has in its place and in its turn contributed to a re-creation."

CHAPTER II.

ROCKS.

HAVING thus cleared away the great obstructions to a little history of natural causes, I will briefly endeavour to interpret the case of so-called igneous rocks, and I propose turning to such authorities as I find at hand to aid me for the system I uphold, or against that which I condemn. Page tells us at p. 336, "There are really very few phenomena in the crust of the earth that cannot be accounted for by existing causes." It is from existing causes that I draw all my conclusions, and working upon these, I beg my readers to Nature.

> "First follow nature, and your judgment frame
> By her just standard, which is still the same."

In a little book called "Our World: its Rocks and Fossils," I find, "Men of science tell us with confidence that the first really solid ground was granite, a hard, fire-baked substance." Though there may

be on the face of the earth many examples of granite masses, which have been subjected to the action of fire, I venture here to assert, in contra- Granite. diction to the men of science alluded to, that granite, as a rule, is not a fire-born rock. But the reasons for this broad assertion are so intimately connected with another phenomenon, that I prefer giving the details there, contenting myself with saying here, that if they had been ejected into their present position in a state of molten liquidity, the strata bordering upon them could not have maintained the conditions which they have done, as shown in page 8.

Of the trappean rocks there are many which have undoubtedly been acted on by fire; but to show the difficulty of pointing to any one rock as of igneous origin, Mr. D. Forbes, in describing certain experiments in the *Chemical News*, Oct. Basalt. 23, 1868, tells us, "the specific gravity of the Rowley rag was found to be 2·84 (sp. gr.)," and that when melted, and cooled again, "the completely devitrified product" possessed exactly the same density—the rock, in fact, resumed its normal condition. But to make the subject more complete, Mr. Forbes, in replying to a question in the *Athenæum*, Feb. 13,

1869, wrote, "that portions of the so-called artificial stone could not, even upon minute inspection, be distinguished from the original basaltic rock." As we have no more experienced eye than that of Mr. Forbes, it is not unlikely that many of the trappean rocks have improperly been called of fire origin. There are in India hundreds of miles of high basaltic hills in regions unconscious of volcanic excitement, so that we have two reasons for doubting the evidence, or the assertions, which give these rocks an igneous source.

The surface substance regarding which, there can be no doubt, is lava; my Encyclopædia defines it as consisting of "mineral substances which are emptied in a melted state from volcanic vents;" it is then a converted substance, its conversion has been caused by heat, and we shall presently see what it was before it underwent this ordeal. We all know what a variety of aspect, which lava from the same, or from different volcanoes, presents; and Mr. Forbes was kind enough to tell us (*Athenæum*, Feb. 13, 1869) "that the lavas emitted by active volcanoes are of two very different characters;" one is "analogous to the old granite in chemical composition," and the other "is nearly if not quite identical with the basalts." Lava.

I may remark in passing, that if the fire of a volcano melts basalt and granite at different times, each of these rocks must be in a position to be affected by the fire, and each is in turn liable to be so converted in appearance, that analysis only can detect the composition; hence we may safely assume that all granite or basalt, subjected to the action of *great* fires within the earth, would, as lava does, lose their basaltic and granitic appearance.

How made. I will now ask, What is lava? is it an original composition sent to the surface from the interior of the earth, through a distance of 20, 25, or 800 miles, or is it only an altered or a reconstructed surface rock? Von Buch thought that all lavas were modifications of trachyte; Dr. Daubeny thought trachyte was derived from granite; and Mr. Forbes says one is of granite, and one lava of basalt. These two rocks, then, are of a fusible nature, and can be converted into a liquid state similar to that of the sand in our glass manufactories, or the slag in our iron furnaces. There is, then, no difficulty in allowing that lava is a reconstruction from these two rocks, the granites and the basalts are of varied aspect and condition,

the lava follows these varieties; but the following extract from an analysis in the *Athenæum* of Feb. 13, 1869, shows that they possess many ingredients common to both:—

Ingredients.	Lava Trachyte, Iceland.	Pyroxenic, Etna.	Vesuvius.
Silica..................	73·37	49·27	39
Lime..................	2·49	10·38	18
Magnesia	1·52	3·76	3
Alkalies	5·36	5·67	11

All these varieties of lava, and many more, are ejected from this earth by a concealed force. The ejection is attended with fire; as fire cannot exist without air, there must be air at the source of heat. If we examine the working of a common blast furnace, we find that as the ore within becomes melted it sinks to the bottom, while the silicated contents rise to the surface, and if not prevented by the placing of certain materials within the top of the furnace, they would boil over the edge of the furnace, exactly as lava boils over the edge of a volcano. I will assume, then, that as there is air in the furnace, there must be air in the mountain. If the external atmosphere alone supplied this air, there is no reason why the effect on the interior should not

Fire depe-
dent on ai

be continued; the action of the volcano is, however, spasmodic and uncertain, and, consequently, the supplies of air must partake of the same character.

As there is nothing in nature without a rule, we must endeavour to find one for this fickle and intermittent force. Few of those who read this paper will be far from the spot where they can verify what I write: they have only to look at the fire in the grate; it is burning bright and calm, with an equable draft of external air; place some fresh coals on the fire, in a few seconds the imprisoned gases escape, first in smoke, then in flame, while here and there bright jets rush fiercely from the bubbling lumps of coal. The rule of all nature is before us: every escape of gas gives an increase of air; the foundation of the volcanic mass is the fire-place, where nature of old heaped up her combustible materials; as the air is more confined down there than in our sitting-rooms, the fire once ignited may smoulder, or if it goes out we shall see that it is at any time liable to be lit again. The store of material is vast, and the pent-up gases in the great gasometer of nature are the collections of millions of years. There are several causes which liberate these gases. Water is the great agent,

and this will be treated of in its proper place. The exterior air acts upon the interior, gases are liberated, fields of material burst asunder, masses subside, fires are encouraged by chemical causes, the noises of all these subterranean actions are heard on the surface, earthquakes ensue, the volcanic excitement increases, and, dependent on the quality and quantity of material released for the occasion, up rise through the mountain chimney the gases, the smoke, the stones, the ashes, the fire, and the lava. How ejected.

How, then, did the substances which form the lava get into the position to do so? It is at times poured out in vast quantities, so that there must be vast stores of material; this material must be of a character similar to the granitic and basaltic masses on the surface of the earth, so that the question falls back upon these rocks—how did they get into a position so as to be liable to the action of fire? As the force of fire works upwards, we may conclude that these materials were located above the fire, and were in that position liable to the changes which fire might produce upon them. Some of these effects may be gathered from the experiments of Mr. Forbes, described in Materials used.

the *Chemical News* before quoted. The substance alluded to was Rowley rag stone, which, "after fusion in a reverberatory furnace, and being allowed to cool under different conditions," formed "perfect black glass, less perfect ditto, black glass showing a tendency to devitrification, black glass enclosing devitrified spheres, and a completely devitrified product." There is no occasion to enter here all the varieties which geologists have found for supposed igneous rocks; but if under the manipulation of man one rock is capable of all these changes, we may form a slight idea of the numerous changes which might occur under the agency of nature. Within the volcanic region, masses may have been molten many times over; on each occasion they may have been subjected to varied conditions of heat and cooling, and from every change lava might be discharged, still containing some of the ingredients of the original mass. These ingredients are similar to those contained in our surface rocks, and as the foot of a volcano is on, or sometimes even below, the level of the surrounding country, there is no difficulty in tracing the existence of granitic or basaltic rocks into such a situation. If these rocks

Their situation.

had been ejected into their position at the foot of our volcanoes from a depth of twenty to twenty-five miles, they must necessarily have passed through inflammable materials in a fused and molten condition, which condition must necessarily have ignited the surrounding materials with which they came in contact, and as there is no inherent heat in themselves, either as lava or rocks, they would have rested for ever where they first settled down; but they do not rest, for every now and then they break out again in fierce ejection; there is, therefore, a source of heat still below them, which source will be explained in another place. If, then, these lava-producing rocks rest on or around combustible materials, they did not get there in a molten state; and as we shall see that the combustible materials were lodged by water, we may safely conclude that any matter found upon them was lodged there by the same agency.

How place

As we can see the same work going on daily before our eyes, as our sand beds and broken-up masses of varied sorts can form into granite now, as there are new granites and old granites, as the fine mud of river estuaries is even now

How forme

forming substances similar to basalt, I have no hesitation in saying that basalt is a water sediment of a long and slow growth in still waters, and that granite is a reconstructed mass formed from sands and triturated matter by active waters.

Upon all these materials igneous action has operated in various ways in many parts of the world, chiefly in the carboniferous period; but as it will presently be seen that there are more causes of heat in the earth than one, I will not here confine myself to one cause for the metamorphic rocks scattered over the world. They are found as dykes, veins, and all the numerous offshoots mentioned by Page at p. 116. Every change has its little history, as every variety of tempering the same metal by artificial means has its cause: but the great rule is the same; it has been going on from the time that the first water stream washed off vegetable matter from the surface to form its little delta, and it will go on as long as rain falls from heaven and percolates the earth. Nature never rests; but if the first solid ground upon earth was a molten mass of granite, why does not that art continue? Animal life may have ceased, vegetable productions may

have failed, but fire has not ceased to eject matter from the earth, and that matter is lava—when, why, and how did the change take place? No geologist that I know of has ventured to investigate these questions, and till they are explained I am content to say that neither granite nor basalt in their original state was produced by fire. There is nothing in nature to prove that they were, while all the vast earth below us is full of the productions of air, earth, and water: and it is to these three elements that the origin of everything in nature can be traced. In the next chapter I will explain the origin of heat in the earth. From air, earth, water.

CHAPTER III.

CAUSE OF HEAT IN THE EARTH.

WE must go back to early days of creation to find the natural causes of subterranean fires; to those days when the grass, and the herb, and the tree Heat origin. grew spontaneously when they were consumed neither by beast nor man—when the high lands in every quarter of this globe were rank in vegetation suited to the climate. As it is now, so was it then. The herbage was destroyed by the elements; it lived its short or long life; it died, and it rotted away, or was washed off by the rains of heaven. There was denudation then, as there is now; little rills produced the small ravines; they ran on to the larger courses, and each carried down the contributions of vegetable

matters to build up their own alluvial plains, or to launch them on the wide-spreading ocean.

In those days, this ocean was more extensive than it is now; these British isles had not raised their heads above the wave; but the quantity of water was the same as it is now—as it built up one place, it wore a deep one to match. There was no sudden sinking of the water from the land, and no breaking-up of rocks and precipices, as poetic painters have loved to delineate; but the first lands were deposited by the never-resting sea. In their first condition, these deposits were flat as the mud banks of Southampton Water, the shores of the Mersey, or soft as the sands of the Goodwin. I am not inquiring from whence the first seeds came, or how the herbs grew; it is sufficient here to know that they did grow upon every spot where the contending elements allowed their growth. As this vegetation grew, so it died; as denudating causes began to work the moment the seas had left the spot, so, from the moment vegetation began to fall or to die, it was blown by the winds, or carried by the waters, to aid in the building of the earth. As these laws are at work now, so have they been from all time.

Herbage.

Time of growth.

Imagination may revel in a wilderness of reeds and bushes, grasses and trees; but, accustomed as we are to the cultivated systems of human civilization, we can scarcely picture to ourselves the aspect of this old vegetable world. There are prairies and backwoods in America, impenetrable swamps in Africa, and wild jungles in Asia; but no present conditions of the vegetable world can equal those which existed before animal life began to seek its food from the natural productions of the soil. It is to these fruitful times and these conditions of nature that I now propose to trace back the source of the igneous action in the earth. As, however, I must commence with historical time, we must trust to our imaginations to fill the great gap of uncounted ages.

Example in the Mississippi.

Under the head of fluviatile accumulations, Page gives an account of the labours of the great Mississippi and its tributaries: "The whole alluvial formation from the base of its delta upwards slopes with a very gentle inclination . . . . . of about 200 feet in 800 miles." This deposit consists of mud and sand, with much vegetable matter intermixed, as "may be inferred from the abundance of drift trees floated down every

summer, and which form tangled miscellaneous rafts, sometimes, like that of 1816, no less than 10 miles in length, 220 yards wide, and 8 feet deep." Calculations having been made as to the length of time occupied in forming that which is called the delta, it was found that an area of "13,600 square miles . . . . . . must have taken 67,000 years;" the plain alone must have taken "33,500 more years for its accumulation." And then we are told that this time, 100,500 years, "must be insignificant in a geological point of view, since the bluffs or cliffs bounding the great valley, and therefore older in date, and which are from 50 to 250 feet in perpendicular height, consist in great part of loam, containing terrestrial, fluviatile, and lacustrine shells still inhabiting the same country." Considering that the land here alluded to is but a very small portion of the great valley, we can go on and accept the long periods which have been allowed for the formation of the earth as it is.

In the inaugural address of Dr. Hooker to the British Association, at Norwich, in 1868, six hundred millions of years were talked of as the Time. existence of this world; and philosophers have

assigned to the habitable globe an age far exceeding this period. Allowing, then, the longest calculated period for the working of the Mississippi and its tributaries in forming their own valleys, and bringing down the residue of Nature's productions to the ocean, we find an indescribable period during which vegetable matter has been perpetually washed down. Page says, as it is here, "so with all others, making allowance for the region, climate, and biological provinces with which they are connected." We have, then, an unlimited time during which every river that has at any time emptied itself into the sea, all round the world, has placed at the disposal of the sea a quantity of vegetable materials utterly beyond calculation or imagination. Have time, produce, death, and deposit gone on for nothing?

I can best answer this question by a reference to a subject within our own knowledge. Page tells us: "When the student is reminded of the rafts of the Mississippi, he can have little difficulty

Matter. in forming some conception of the shallow seas, estuaries, and submerged areas in which the sandstones, shales, shell limestone, and coal beds of the carboniferous system were deposited." The

laborious compiler does not expand his ideas sufficiently; there was no need of estuaries or shallow seas for the deposit of matter which now forms our deep coal-pits, for these materials were lodged where we find them when the currents and the eddies washed over the site of our present highest hills. Snowdon, Ben Nevis, and all were then forming below water, and there were no estuaries in these regions to receive the first tributes of the ocean—the deep foundations of these isles, and the present sources of our warmth and light. The deposits of coal from our own vegetable growth came long after the period I have gone back to. Its carriage.

Year after year, for unknown millions of years, in small quantities at first, when earth was young, expanding into incomprehensible masses as she grew larger and more prolific, the surface refuse of the dry land was washed away to the river deltas, to the lakes, and oceans. The clays, the boulders, the gravels, sand, and silt all remained in their respective places, selected for them by the strength of the carrying stream, while the great rafts of unbroken and more solid materials were passed on to the ocean. Winds and currents made their selections from these heterogeneous Its deposit.

masses; and as wave tossed or current drove, they drifted to those places where contending forces whirled them round, where eddies sucked them down, in fact, to all those places where the condition of the currents bade them rest.

Change of climate, alterations in the position of the Poles, and other difficulties, have been fruitlessly argued on, and there have been endless theories in accounting for the presence of tropical productions in arctic regions; but the simple and undoubted cause seems to be, that these products have been wafted on the ocean currents. There is in the Atlantic the well-known Gulf stream, which brings the warm tropical waters to the frozen ocean; and this current brought the vegetation drift of other lands to form our coal seams. Page tells us, that "in some fields as many as 60 seams occur, varying in thickness from a few inches to 4, 6, 8, 10, 12, and 20 feet." He finds a "sameness of external conditions over such extensive areas of the earth as are occupied by our known coal fields." I gather from these facts that similar matters were given over to the ocean; that similar currents brought them, and similar causes stopped them, year after year, till

the space they occupied was filled up. In the intervals between the arrival of these drifts, the ordinary sediments of the waters settled down on the surface of each successive season, leaving between the seams of coal the material we now find there. The thickness of these divisions tell us of the quiet or troubled season, and the thickness of the coal seams tell us of the extent of the yearly supply. By this covering-up of the vegetable matter, it became hermetically sealed; the more perfect the covering, the more securely were the vegetable gases imprisoned.

Its gases imprisoned.

Page tells us (p. 200) that "the interstratified trap tuffs, the basaltic outbursts, and the numerous faults and fissures, testify to a period of intense igneous activity." We have a familiar example of this action in our hot-beds and our hay-ricks. Under certain conditions these vegetable masses ignite, so that without calling in the aid of internal fire, we had in coal deposits a ready cause of heat, and, consequently, of explosion. To this cause, then, I partly assign the changes which have taken place in the strata connected with our coal pits; and proportionate to the quantity of gas liberated by the ex-

Results of their escape.

plosion was the extent of the fissures and dislocations. There are, however, other causes for these, which will be shown hereafter.

Situation of volcanoes.

Continuing the analogy of our hay-ricks, and making our coal-fields the stepping-stone, we come to volcanic action. Volcanic mountains are situated in or near the sea, by lakes, or where lakes and seas have been. I will bring Iceland in as an example. It is situated where the force of the great Gulf stream begins to weaken and subside before the growing force of winds and currents from the north. Tropical productions are even now found upon its shores, and the coal-fields of Iceland are similar to our own. We may then safely say that the Gulf stream, or some other current that held its place in former days, carried with it some of the foundations of Iceland. But as these foundations only rest under certain conditions of opposing waters, we may say that much was added by the meeting of the waters from the Arctic Ocean. When once a bank or mound is formed by the eddies or whirls of water, materials subject to those influences are perpetually lodged upon the mound or bank, so that under a long and uniform system of

meeting currents, these banks are heaped up to the extent of the water power. Under these perpetual forces Iceland began to grow on its ocean foundation. It is not certain whether the island gradually grew by the sinking of the water, or whether it was thrown up from beneath the waves by volcanic forces; appearances indicate the latter. But this is immaterial to the point in view. Our only object is now to show that there are in the foundation of Iceland great causes of igneous action. The results of this force are shown by upwards of thirty volcanic mountains, and by about the same number of small islands composed of lava, large tracts of which traverse Iceland in all directions, while other mineral masses indicate their igneous origins. There are no appearances of stratification, and there are but few rocks on the island which do not bear external marks of heat. The most remarkable phenomena are the intermitting hot springs of different temperatures, and in other parts of the island there are cauldrons of boiling mud in constant activity, sending up clouds of vapour, so that, with the aid of the geographical dictionary, I establish the fact of great igneous action, past

Cause of igneous action.

and present, on the island of Iceland. Of the thirty volcanic mountains, Hecla is the only active one. If the lava which was forced up in olden time had ascended by the contractile force of the rocks from an internal reservoir of molten matter, why was the passage stopped? We may suppose that the crust of the earth would have a better chance of cooling and contracting here than in the tropics, and while the internal supply of liquid matter was available, there could be no reason for such stoppages; but the old passages for the emission of lava have closed in Iceland as well as in many other regions of the earth. Lava no longer flows from the thirty mountains, but from Hecla only; there is, then, beneath Hecla a continued cause of igneous action, occasionally of vast power. While the theory of internal fire and contraction of the earth's crust can in no possible way account for these closings and openings—the extinction of one fire, and the ignition of another—it will eventually be seen that my drift system supplies a full explanation. Hecla continues its activity because its heat-producing foundation is not exhausted; the fires of the other mountains are extinct because their

Working of igneous action.

heating causes have been locally exhausted; and it will be seen hereafter, that under this system no volcanic phenomenon could by any possibility last for ever; while, under the general geological belief system, there is no reason why a volcano once begun should ever cease. Under this theory we have no certain proof of the existence of fire. Under the natural system, now described, there is no more room to doubt the existence of buried gases and heating material, than there is room to doubt their effects in a burnt hay-rick or an exploded cargo of coals. There are many minor details of subsidiary heating causes which are reserved for the minor phenomena. In this chapter I have only brought forward the first great cause of igneous action in the earth, and as its existing cause has been exemplified in one place, so it may be held to originate in every locality where volcanic influence is felt.

Its unlimited time.

When we think of the time occupied in depositing these materials as part of the foundations of dry land; when we think of the vast mountains that these materials have forced up from beneath the ocean, and from beneath the earth, in all parts of the world, we have before

us an immeasurable space of time, since the grass, the herb, and the tree first grew spontaneously upon earth; but during all that time we can recognise but one great Ruler, displaying, through time unknown to man, an arrangement of life, death, burial, and resurrection, of which man is even now reaping the harvest.

Natural cause of internal heat.

So far have I traced the subterranean fires to their true and natural causes. There is one great rule in the system, but there are uncounted issues to that rule. I propose to take one of these issues (Hot Springs) for the next chapter.

CHAPTER IV.

HOT SPRINGS.

How many of us seek these natural medicines? how many of us are benefited by their use? how few ever think of their origin! and how few of those who have done so have found it out! Many years ago I met two Englishmen on board a steamboat, between Trieste and Ancona: they were afflicted with gout and rheumatism; they thought that the German hot baths had improved their health during the past summer, and they hoped that the pleasant climate of a Roman winter would enable them to continue in the enjoyment of life. Southern heavens gave their warmth, and hot springs flowed only for the benefit of man. He might outrage all the gifts of Nature as he pleased, but Nature was held

subservient to his wants; the how or the why of her ministering powers were points unthought of. I have watched the anxious looks of those whose dire necessities sought relief in the shady baths and bubbling waters of the sunless Pfeffers; they could calculate the effect of each draught as they walked up and down that gloomy room; a portion of their lost health might be recovered, but their ruined bodies had extracted from their weakened minds the power of thought; the rocks gave out the springs as a matter of course. I have chatted with the gay and fashionable throng round the springing waters of beautiful Carlsbad, and smiled at the oft-repeated remark, "Why do you not drink the waters? if you are not ill, you should do so for fashion sake." Here was another ruling passion; and we understood the motives of many, whose cheeks were daily growing pallid from the oft-repeated services of the fair nymphs, who drew the sparkling cups from the Sprudel-Brunen. It was far beyond fashion to think of the source of its gratification. I have visited strange and lonely places, where steaming waters have gushed from the fissured rocks to be mixed and lost in the passing stream, and have watched the hot water rushing from

Where do they come from?

the mouth of the sculptured cow, and falling into the capacious reservoir of an ancient Hindoo shrine, to which the Brahmin, whom I found in the water, officiated as priest; full of faith, but pale as death—too thin to be eaten by his neighbours the tigers—this solitary ascetic revelled in the pool where we could scarcely retain our fingers for the heat. Where does it come from? With a leaden look of rebuke, and in a sepulchral tone, the devotee replied, "From God." It was a better answer than I ever got in Europe; and this poor heathen, tending with care the stone images of his shrine, placed his final thoughts on the eternal Bugwan (God). From time unknown hot mineral springs have been looked on with veneration all over the world. Temples and baths have been built, and nations of the East have gathered to the purifying sources with as much zest as they of Europe now flock to the springs of Carlsbad or Ischia. But the fanes and the baths have been left desolate. Perhaps a few priests may be found upon the spot, but the ordinary inhabitants are wild beasts and reptiles.

When I seek from science an answer to my question, Where does the hot water come from? Science tells us.

I find plenty of confident assertions, the truth of which I will endeavour to discover. Page tells us in his text-book, page 27, "Respecting the heat of the interior, we see it abundantly manifested in hot springs." Many geologists have supposed that these springs are evidences of an internal inherent heat within the earth, but I take the words of Page, as he is the great collator of the opinions of others. The latest authoritative explanation of the subject is in "Vesuvius," by Professor John Phillips, of Oxford. At page 327 I find, "By frequent trials it is found, in many parts of Europe, that the temperature of water issuing under these circumstances rises 1° Fahr. for every 50 feet of descent, sometimes 1° in 45 feet, and again 1° in 60. Applying this scale to the water of Bath, which issues in abundance at 110°, the mean annual temperature of the city being 50°, we have $60 \times 50 = 3,000$ feet for the depth in the earth represented by the temperature of the spring;" or, in other words, the waters find their heating cause at that depth, and rise to the surface by ordinary hydrostatic pressure.

Science. There are two points to be considered in this quotation,—How does the water rise from that

depth? and how can we depend on the trials referred to?

As to these trials, they appear to have been made in wells and mines, but I deny that any proof of internal heat within the earth can be found in places to which external air has access. The bottom of a well is warm because the air has no natural circulation; the heavy gases press downwards—they become stagnant; and as the pressure from above increases with the depth, the atmosphere at the bottom becomes foul and heated. The same holds good of mines; but I may say, in addition to this, that coal mines especially give no evidence of a universal heat, because they have within them plentiful causes of local heat. I can go further upon this point, and show what confusion would prevail in the interior of the earth, if this progressive scale of heat existed. I am acquainted with two boiling springs, one at Arawud in the Khandesh, one at Wuzzerebai in the Concan. The difference of elevation of these two surface springs is at least 2,000 feet, so that as they both boil at the issue, there must be that difference between the boiling sources, supposing the boiling point is found, as Mr. Phillips implies,

at a fixed distance from the surface, irrespective of the elevation of that surface; that he does mean this is shown by his telling us, that according to the scale the temperature of boiling water "would be found, it is probable, under London at about $162 \times 50 = 8,100$ feet."

There is, however, a greater difficulty upon this point as to the place from which to reckon for this increasing heat. According to Page, the mean temperature of the ocean ($39\frac{1}{2}°$) is found at the equator at a depth of 1,200 fathoms, and all depths below; but according to the *Athenæum*, Sept. 4th, 1869, 36° 4″ is mentioned as the lowest temperature of great depths, as discovered by recent experiments; so that I naturally ask, At what level below the ocean-bottom does the inherent heat of the earth begin? Wherever that may be, the system leads into the idea of a vast interior of heat undulating as the exterior of the earth, and utterly upsetting the idea of Mr. David Forbes, elsewhere referred to, of the molten mass of matter in the interior revolving with its envelope as one entire body. I cannot but conclude on this

Considered. point that the experiments in the ocean are true, because no external air was admitted with the

thermometer; while the trials beneath the earth cannot be true, because external air was admitted.

The second point is, How does the water rise from the depth of 3,000 feet by ordinary hydrostatic pressure? Several mechanical conditions are required for this effect,—1st, a head of water on a higher level than the issue; 2nd, a firm and compact stratum of earth to secure a descending, as well as an ascending pressure; 3rd, a large reservoir at the extreme depth. These necessary mechanical conditions do not exist in the Bath district. On turning to Falconer's "Baths of Bath," I find that the district is hilly, that it contains "great oolite, Fuller's earth, inferior oolite, oolitic sand, marlstone, alluvial soil, upper and red sandstones, marls, and coal measures." It is through all these varied and fissured strata that we are asked to believe in a down-fall and up-cast channel 3,000 feet in length each, to furnish the Science not correct. waters for several distinct springs, rising out of one alluvial bed of a few hundred yards in length and breadth. I have no hesitation in saying that such an arrangement does not exist within this district; and further, that there is no head of water above the level of the springs to exercise

the required pressure, and consequently that there is no need for a supposed heating reservoir at a depth of 3,000 feet from the surface.

Local and natural causes considered.

I will now endeavour to prove that there is no occasion for any of these appliances, but that the heating causes are perpetually supplied to the alluvial valley, from which the hot springs issue, by local and natural causes. Page tells us "that the metallic basis of the alkalies and earth, the moment they come in contact with water, are decomposed with an evolution of intense heat." We find in "*The Academy*" of December 11th, 1869, that "Julius Thomsen, of Copenhagen, in his researches upon the heat evolved in neutralizing acids, finds that when hydrocoloric acid is neutralized with hydrate of soda, an amount of heat is liberated which is proportional to the quantity of acid neutralized. This holds good until the acid and alkali are in equal equivalents. But if the acid be in excess, less than the proportional quantity of heat is set free." We shall find, on a reference to Falconer, that not only do the Bath waters show the presence of the alkalies, but also of the neutralizing qualities, so that the heat of *each separate spring* may be held to be adjusted

by the accidental mixtures of the causes of heat and neutralization.

Having, then, the chemical causes of heat in water, I have to consider how the materials necessary for this effect got into the alluvial soil from which the hot springs of Bath issue. Falconer tells us that the waters contain nitrogen, oxygen, carbonic acid, and marsh gases, thus proving that they had been in contact with decomposing carbonaceous and vegetable substances. The history of these matters and gases is so beautiful, that I hope to be pardoned for dilating upon it, and carrying the reader back to the original formation of the district. The varied strata have already been named; all are of water deposit; so that it must first be considered how the waters worked upon the entire surface. Any one may acquire a knowledge of this working by a careful inspection of any estuary. There are tides and currents at work with their eddies and their whirls. It will be discovered that these offshoots deposit the light materials, while the heavier are laid along the course of the main channels. The great mud banks of our Southampton waters appear all soft, but there are firm spots upon them, while the

First causes, how produced.

bed of the tidal channel has comparatively a firm hard bottom. In consequence of this water action, there is a firm and a soft deposit. This system spread over the entire Bath district in long past times. The present hills declare the tidal or other channels, while the present valleys declare the influence of the eddies and the whirls. In the latter were deposited all the lighter materials; on the former sites the firmer materials settled down. As by slow and sure degrees these deposits grew, so by slow and sure degrees the water was expelled; and from the moment of that expulsion, atmospherical causes brought about the ordinary denudation of the surface.

Looking at these valleys now, we can comprehend that while the harder materials have resisted in a measure the never-ending attacks of summer's heat and winter's cold, of the rain-fall and the wind-storm, that these forces have carried off the whole of the materials which once filled the now empty space. These valleys are some hundreds of feet in depth, and must have contained vast quantities of matter; of this matter the greatest part was a vegetable *debris*. In all collections of this material there are gases, and

Secondary causes.

according to their nature they are liable to heat. Page tells us that the carboniferous period "was one of intense igneous activity." These valleys, then, being full of vegetable matter intermixed with all the materials available for the water carriage, were of course liable to such a degree of heat as to refine and purify the materials subjected to it; the results of this heat are now traced in the hot springs. When the Leper Bladud wallowed in the warm mud of this alluvial valley with his pigs, the effects of the heating causes were visible, and, as Warner tells us, ever since (44 A.D.), man has paid his respects to these healing springs. The origin of their virtues consists in the carbonates, the sulphates, the chlorides, the alkalies, and the acids, all gathered by the first water deposits, refined and manufactured by the heat which those deposits contained.

Connecting causes.

It is necessary now to connect these materials with the present state of things. Every one who has been at Bath knows that it is chiefly supplied with water from surface-springs on the hillsides; this high outflow is caused by the formation of the district. As the rain falls it percolates through the surface-soils till it reaches the harder

Water. rocks, it then runs along their faces, which, every here and there cropping up, conduct the waters which they carry to the surface; these springs supply beautiful and very pure water. While some percolations soon find an exit, others are carried down through the hills till they reach the alluvial valley, and in every inch of their devious courses through many strata, they are collecting such materials as they can carry with them; and it is sufficiently proved by the analysis of the waters,*

* I have no complete analysis of the hot springs of Bath, but the following extract from Falconer will show the correctness of the text:—

In an imperial gallon, 70,000 grains.	By Markand Galloway. 1848.	Comparative heat of some of the hot springs mentioned by Falconer.	Fahr.
Carbonate of Lime... ...	8·820	Borcetta	171°
Carbonate of Magnesia ...	0·329	Wiesbaden	158°
Carbonate of Oxide of Iron	1·071	Aix-la-Chapelle ...	130°
Sulphate of Lime	80·052	Teplitz	121°
Sulphate of Potassa ...	4·641	Bath Hot Bath... ...	120°
Sulphate of Soda	19·229	King's Bath ...	117°
Chloride of Sodium ...	12·642	Kingston Baths	108°
Chloride of Magnesium..	14·581	Cross Bath ...	104°
Silicic Acid	2·982	Pfeffers	99°
	144·018		
Carbonic Acid...	26·45 c. i. at 115° F.		

Recently, however, Roscoe, of Manchester, has discovered lithium and strontium, the metallic bases of the alkalies strontia and *lithia.* The gases evolved from the waters are carbonic acid,

that the materials carried with them are conducive to heat. As, then, these trickling subterranean streams work downwards, they come to the materials which had long ago been subjected to the natural heating causes; these materials, gathered over and upon the faces of the harder strata, offer themselves to the perpetual erosion of every trickle, so that the alluvial valley is kept perpetually supplied with the bases of the metallic alkalies, with water to create the heat, and with the acids to modify that heat. There can be no more natural or beautiful arrangement than this; the whole process is patent to us, and yet science has ignored nature, and endeavoured to find heating causes from an unknown source. Action. Result.

I find a still further proof of the local origin of heat for these springs. If all hot springs came

nitrogen, and oxygen. These quantities are taken from the King's Bath, but they are found to vary with each analysis.

STATEMENT OF MINERAL INGREDIENTS FOUND IN HOT SPRINGS IN 16 OUNCES OF WATER.

	Grains.		Grains.
Teplitz	4·854	Romerbad	2·239
Warmbrunn	4·07	Gastein	2·68
Wildbad	3·58	Bath	17·96
Pfeffers	2·61		

So that the ingredients of these springs vary in each, and in any particular one at different times, quite excluding the idea that they derive their heat from one general cause.

from one great source, then all would, on analysis, give the same contents; but no two springs do so; they all have certain alkalies and acids in them, but these vary in their proportions, while other materials are very various. It may be alleged that these varieties may be dependent on the strata through which the waters rise, but I answer that they rise from the alluvial soil which they themselves have formed, and that no one can prove to the contrary; moreover, that these alluvial valleys are divided beneath the surface by the same hills or banks which we see above. In *Land and Water*, of September 25th, 1869, we are told that "the adjacent springs of Cappone and Bagno Fresco (Ischia) are often mixed with the water of Gurgitello to modify its strength." Falconer tells us that in 1835, by "the digging of a well 170 feet deep, at a distance on the west of 250 yards from the King's and Queen's Baths, and 200 yards from the Hot and Cross Baths, the stream of hot water burst into and overflowed the well, and the supply to all the baths, except the Kingston Baths, was materially diminished." I thus prove not only the principle of different *sources, but again* refute the hypothesis of Pro-

Another proof of local heat.

fessor Phillips, by showing that as the water supplies for the Bath springs extend over a space of 250 yards in one direction, the mechanical arrangement necessary to carry out his plan could not by any possibility exist. I also show that the Bathwick or Lansdown hills continue their firm strata below as they do above the surface, and to their continuations may be assigned the divisions which exist between neighbouring springs.

In different sources.

Emperors have employed their time in fathoming with rods the sources of hot springs. Carlsbad has been much harassed by these inquiries. Geologists have calculated on the extent of internal cavities by a computation of the quantity of matter brought to the surface by the waters. Bath produces large quantities of sulphate of lime and chloride of sodium; Carlsbad sends up plenty of silicious lime; while the orifices of the Geysers in Iceland are covered with a silicious matter; but no vast caverns are forming by these causes. The waters that trickle beneath the surface of the neighbouring hills perpetually bring down materials with them; their separate contributions are small, but the aggregates are large; there are on the hillsides little subsidings and little

Denudation.

How supplied.

landslips.* The causes of these phenomena are not much thought of, but they go to fill up the small subterranean erosions made below them by the ever-destructive trickle.

Interior work.

Thus, then, nature has built up, and nature has pulled down; there is much to admire in both actions, but as a rule, man looks upon the rugged hill, the sparkling spring, and all the surrounding scenery as simply beautiful in their exterior. If he would dive into the inner workings, and go into the details which I have here so briefly sketched, he would find that the wonders of the interior far surpassed the outward show; he would see first the wild growth and the inevitable death; he might trace the water burial and the long silent resurrection, the natural decay and the unavoidable amalgamations of chemical changes, and he might trace how the sunlight of old is even now beneficial to man, who lives, perhaps, millions of years after the alkalies and gases I am writing of were component parts of living organisms.

There is nothing left to imagination in the system here imperfectly described, while it appears

* It is not difficult to foretell when these phenomena are likely to occur; a drier summer than usual, followed by sudden autumnal heavy rains, are seasons almost certain to be marked by hill landslips and coast subsidings.

to my poor comprehension that the elaborate arguments of geological professors have failed to prove any connection of hot springs with a supposed inherent internal heat of the earth. It is difficult to describe a system which is every moment before our eyes so perfectly as to convince every one of its truth. There may be found those who love the mysterious and mythical fires of inner earth more than the self-evident system of growth, decay, burial, and resurrection; such may accept the rise of hot water through impossible strata 3,000 feet in thickness, in preference to the ordinary flow of water to its level, but I ask those who are not wedded to any particular theory, to consider the plain tale I have placed before them, and I fear not that their conclusions will be that the causes of hot springs are local, and in no way dependent on a progressing scale of heat which is supposed to exist within this earth.

Conclusion.

Hot-springs do not come from an inherent internal heat.

But from local causes.

Having thus described one of the most ordinary phenomena of the surface rising from interior causes, I will in the next chapter continue the same beautiful and wonderful system which, perpetually working beneath our feet, is the chief cause of the earthquake.

CHAPTER V.

EARTHQUAKES.

FROM long before the birth of our Saviour, man has been busy in his attempts to find out what
Earthquake. makes an earthquake; but it seems from a carefully-written article in the *Quarterly Review*, 1st January, 1869, that no one has as yet been successful, for the paper ends thus: "Surely it is the part of experimental philosophy, and the followers of Newton, to complete the study of the forces which now agitate our globe, and thus to obtain a sure basis for reasoning on the vicissitudes which it has undergone." I hope the writer will excuse me for saying that no one has any study to complete; the present generation require to forget all that they have learned, and go back to Anaximenes, who thought, some 500 years B.C., that earthquakes

were due to "dryings and moistenings, which produce fractures, displacements, and shocks." (*Quarterly*, 1st January, 1869, p. 97.) We cannot, however, pass at once into the natural system, without saying a few words on some of the theories discussed by the *Quarterly*. Like a great many others, the writer asks, "What makes an earthquake?" He replies: "Local displacement of the rock by the application of force! What force? Are there cavities in the earth into which, or out of which, steam may violently rush, and so shake everything around? or can there be falls of rock in subterranean hollows, so as by their hammer-strokes to produce a like effect? or can the rocks be rent with violence, and thus at once fissures be produced, masses displaced, and steam allowed to expand?" It will be seen, presently, how near one of these questions is to the truth; but the author, passing close to the brink, goes on to tell us, that "the most popular of all the general notions of change in the interior of the earth is the hypothesis of contraction of the mass of the globe by radiation of heat into space." I believe that this question of contraction is satisfactorily disposed of in a previous chapter; but however hot some of our

interior rocks may be, it has been generally allowed that there is no system of general heat radiating from the centre of the earth to the exterior. We are told that this contracting "speculation is too firmly rooted to be easily dethroned;" and yet the throne, even in the estimation of the *Quarterly*, is not secure, for he continues: "To make it effectual, however, it is quite essential to adopt the further opinion that the earth, at the basis of volcanic regions, is still fluid with heat—internal fire, not central fire, but a zone of fluid rock under some ten, twenty, or more miles of rock. The zone may not be continuous, it may be divided by solid partitions; but there must be such a zone to supply the irregular but irrepressible demands of the volcano." We shall see about the stability of the throne by-and-by; but as the demands of a volcano are paid in heavy drafts of lava, which lava is composed of basalt, granite, and other of our hardest rocks, I ask the question, in passing, of what rock are the "solid partitions" supposed to be? I have no hesitation in saying that such a condition of things does not exist; the reasons will be hereafter explained, but this *effectual* support of a tottering throne is at once cast away.

Having thus far cleared the distant horizon of the haze cast around by the struggles of those who have delved with unrequited labour to solve their own great question of what makes an earthquake, I will now endeavour to interpret the natural earthquake systems. There are two, but as both derive their origin from the perpetual antagonism between earth and water, I must necessarily take their history from the beginning. Earthquake—two causes.

First, of what does the earthly element consist? Of a firm or tenacious bed, impermeable to water, over which we find varied strata composed of sands, clays, limestone, silex, minerals, metals, rocks, and muds, in which, and amongst which, are found the remains of every animal or vegetable that ever found nourishment in the soil, or breathed the air of heaven. A portion of every grade in Nature's kingdom has returned to the dust from which it sprung, and gives back to that dust the very elements it borrowed from it. For millions of years this refuse has been blown away by the wind, and washed away by the water. These two elements have, in their ordinary capacities, great powers of discrimination; the light matters are blown and washed together, the adhesive matters History. Wind, water.

settle down together, and the water re-arranges all entrusted to its care with wondrous ability. Most of this sedimentary stratified material is permeable to water; but there are found, associated with these, other materials, which retain water on their surface.

Over all this vast amount of matter the copious rain of heaven descends; it percolates through the

On earth.

permeable strata, and it rests on the impermeable rocks and other substances, following the course or the incline of these substances, whatever they may be. Or, as Professor D. T. Ansted tells us, at p. 51, *Springs and Water Supply*, "The nature of rocks, then, the mode in which they are arranged, and the mechanical conditions under which they are presented to the action of water,—these are the points that govern the course of that part of the rainfall

Percolation.

of a district that is absorbed into the soil," but "reaching the impermeable beds, will remain on the surface" of that bed as long as it retains its impermeable condition. This condition appears to be very permanent; wells in the Lybian desert,

Waterlevel.

supposed to be 4,000 years old, have lately been "successfully restored to use" (Ansted); and he tells us of the artesian well at Grenelle, of 1,800

feet in depth, from which "the first rush of water was at the rate of nearly a million of gallons per day, rising 120 feet above the surface." Wells are common in all countries, and in all hills may be found springs of water gushing to the surface.

We all know the effect of running water upon our river courses; erosion, more or less, is always going on, and as this result happens before our eyes, so, wherever water runs in subterranean channels, there must be erosion going on there; and as water appears to be everywhere, at varied depths below the surface, there must be a perpetual washing away of matter down below. The matter washed away is that matter most liable to the action of water; thus Ansted tells us that some mineral springs in France "bring to the surface upwards of 1,600 tons weight per annum of various salts." As the material thus liable to the action of water is not the material of which the impermeable bed is composed, it follows that the waste of material comes from the sides or top of the subterranean channel.

Waste of material.

Under this system of perpetual wasting, there must either be a continued supply dropping into the channel with the percolation, or there must be

hollow places worn away by the perpetual stream running over its impermeable bed. In cases where the water-run is more dependent on the supplies from high ground than on the percolation of rain immediately over it, it follows that as long as the water runs, so long will material wash away with the water, and cavities will be left commensurate with the force of the stream, as well as with the consistency of the soil acted on. A case in point was noticed in the *Athenæum* of 9th October, 1869, p. 470: "We find in the proceedings of the Asiatic Society of Bengal for June last, a statement of the effect of an earthquake, which is worth notice. In

Example.

November last, a shock was felt at Murwut. The underground moisture of that season is commonly found two feet below the surface; but it rose after the earthquake to about six inches below the surface, not in one spot only, but throughout all the sandy tracts of the district." As the phenomenon was familiar to me, I wrote briefly (*Athenæum,* 16th October), "That either the earthquake released water from a higher level, or the sandy plains subsided into a lower level. This is most likely to have happened, and its history is simple. Water running beneath the sand upon a harder stratum

gradually eroded the soft matter above it, and this soft matter perpetually pressing down, fell at last into the cavity made by the water, and filling it up, pressed the water upwards, so that instead of being, as usual, two feet below, the moisture reached to within six inches of the surface. These subsidings are so slight superficially, that they are scarcely observed, for though the soil has sunk, yet in its loosened state it occupies a much larger space than when it was firm and unmoved." In these few words we have a whole history of an earthquake shock. This shock was doubtless caused by an extensive and simultaneous sinking of the sand; the shock was felt, and as no depression was visible, the commotion was very naturally called an earthquake. This was a case where the lightness or want of tenacity in the soil allowed it to give way from inability to support itself; but as no two soils are of similar consistency, I will give an example of another kind. A very considerable landslip occurred at Folkestone on the 25th February, 1869; a short account of it is contained in the June number of the *Folkestone History Society*, from which I borrow some details: "A long narrow strip of land, almost half a mile in length, and from Example.

50 to 70 yards wide, has sunk down, so quietly and evenly as to have scarcely misplaced a single stone or bush through some 15 feet on one side of it and five feet on the other.". . . . . . "As far as I have been able to make out, there is nowhere any thrust of the seaward slopes on to the shore; but some 50 or 80 yards from the foot of this seaward slope there has appeared a very remarkable ridge." This slip occurred on a piece of land called the Warren, situated between the Folkestone and Dover Railway and the sea beach. The whole of this Warren is one great slip, and parts of it are said to be always on the move: the surface-soil is the ordinary soil of chalk downs, next comes chalk, and below this is gault. Over this clay, and underneath the chalk, are plentiful supplies of water; and, continues the writer, "You must remember what unusually heavy rains we have had, and how the underground streams must, consequently, have been swollen." The gault has at length been unable any longer to support the superincumbent chalk, and the whole, being in a state of unstable equilibrium for some time past, sunk "upon the surface of a tenacious mud," so that the fall was "gradual and steady." As no

one lives on this spot, I conclude that this is a supposition, for, on looking over the situation in August, I found the place full of fissures, dislocations, and sinkings, which would have gone far to make any one believe who had been living on the spot that he was enduring all the horrors of a very considerable earthquake. This point, however, is not necessary to my history. In the Murwut case the sandy soil sank bodily into the water, and the escape for the liquid was upwards through the friable soil; in the Folkestone case the upper soil, not being of a friable consistency, and mud taking the place of water, this mud was forced by the pressure into the only channel open to it. All along this sea beach, at various points between the cliffs and low-water mark, are many fresh-water issues, and along the course of these channels the gault was pressed, till, by its rising mass (corresponding with the subsidence some hundred yards distant), the light materials of the sandy beach were raised up into "the remarkable ridge." Application.

As rain falls more or less upon the entire surface of the earth, there must be a perpetual percolation or running off from the surface, either into the streams on the surface of the earth, or into its sub- Rain gives subterranean water.

terranean channels. We know by the conditions of our wells that the depth of these water-runs is very uncertain; but a geological knowledge of a district instructs us where to find them. Assuming, then, that there are underground streams of water all over the earth, it follows that there must be a perpetual erosion, and a perpetual softening of the varied materials along the water levels, and consequently the upper permeable strata are left without any support, or a very soft or insecure one. These unsupported spots are, then, liable to fall; but this liability depends on their tenacity, their strength, and side supports which exist around them. If there is an escape for the soft support, as at Folkestone, the upper strata must fall; if there is no tenacity of the upper stratum, as at Murwut, it must fall. In England our subterranean water-courses are small, and of various depths, so that no great surface area is liable to rest over or upon the stratum which forms a water bed; consequently, the side supports do not give way, and the consistency of the strata supports them. Nevertheless, we have earthquake shocks, landslips, and subsidences. A sand deposit will produce the latter;

Erosions.

erosion of matter on a slope or on a flat will

produce the former. It is, however, in countries of greater extent, where the primary formations of the strata are due to the same influences, that the shocks of these phenomena are felt in all their power. Cause. Shocks.

The Lisbon earthquake, says the *Quarterly*, "extended its ravages over an area of 4,000 miles in diameter. The earth groaned, and shook itself quickly and shortly, and then violently, so as to fissure and upset the greatest part of the city." A newly-built and massive quay was swallowed up with the thousands of people who had taken refuge on it from their city ruin, little thinking that their own weight and the tramp of their many feet would aid in the danger from which they fled. "The sea bed was temporarily raised and let fall; the bar was laid dry for a time, and then covered fifty feet deep by the violently returning sea. The whole work of destruction was ended in six minutes, during which several shocks occurred, but one was pre-eminent in force." No description could better illustrate the great water system of erosion. Here is a large district formed from the same materials, and therefore liable to the same forces acting upon them. There was a subsidence, and the weak part rose in the sea; the thrust from the land raised it, Example.

with its light, broken-up material, and the sea immediately returned to find its level through that crumbling mass. In strata composed of heterogeneous materials, some were more adhesive than others; the light and friable fell first, and their shocks brought on the great catastrophe; and then the end came—the whole subsidence. The earthquake was over in six minutes; and from the 1st November, 1755, till 1869, how many theories have been invented for the cause?

Example. The Calabrian earthquakes give an example of the same force acting on a different surface: they lasted from 1783 to 1786, within diameters of of 30, 40, or 72 miles; fissures were made up to 105 feet broad; great gulfs were opened of "300 and 750 feet square;" a mountain was cleft in two, and there were "many cases of extraordinary landslip, upbursts of water and sand." Here, again, the moving force is shown—the fissures ran to a depth of "225 feet." Through such orifices sand and water were forced up. Sand and water must then have been the matter into which the fissured strata sunk; the bed below this sand and water must have been firm, consistent, and impermeable, or the water would not have been there; and if the force had

risen from below this water bed, the water must have sunk through the fissures made by this force, and no water would have risen to the surface. Water, then, must have been the moving cause, and the sand must have been the eroded material from the rocks which rested over the water, so that hollows dependent on the hardness of the stratum were excavated by the constant running stream, till, in the course of three years, the unsupported spots had sunk, and "not fewer than 215 lakes or morasses were occasioned by displacement of the ground;" or, as the *Quarterly* says of other regions, "everywhere violent vibrations, downsliding of hills, stoppage of rivers, formation of morasses and lakes, inrushing of sea waves—nowhere a record of elevated tracts of land."

Argument.

It is curious to see how near some of our great geologists have been to the real cause of earthquakes without discovering it. Sir Charles Lyell has in particular studied the subject of subsidings, fissures, and upheavals; and, talking of the earthquake in Chili in the month of November, 1822, he says: "The shock was felt simultaneously throughout a space of 1,200 miles from north to south. When the district of Valparaiso was examined on

Science near the mark, but the only cause is due to water.

the morning after the shock, it was found that the whole line of coast for above 100 miles was raised above its former level" to three or four feet. "Part of the bed of the sea . . . . remained bare and dry at high water;" but Sir Charles did not detect that in this little history was hidden the true cause of the earthquake. The district is extensive, and its constitution similar; the same force acted here as on the small plot of land at Folkestone, and the weak portion of the strata was below high-water mark. We have no proof of the existence of any other force but water which could create such convulsions.

Having come to this conclusion, I must shortly consider the time of the year in which these disturbances usually take place, and the *Quarterly* supplies the means—"the general result being that the monthly number of earthquakes is decidedly greatest in the first or winter, and last or autumn quarters of the year." The calculations from which this result was drawn seem to have been made for the purpose of fitting earthquake periods into the solar quadratures; but I take the liberty of applying it to a very different purpose. The *Quarterly* considers the results "very remarkable and unexpectedly

Time of earthquakes.

consistent." Allowing that they would have been so in reference to the hypothesis under his consideration, I find that no other results could be expected to follow the system I am following; and I go back to the doctrine of Anaximenes, as mentioned by the *Quarterly*, "who contemplates the earth as subject to dryings and moistenings, which produce fractures, displacements, and shocks." The time of the year, then, in which the greatest number of earthquakes happen is when, there being but little evaporation, and no consumption of water by vegetable growth, all the rain that falls either runs into the surface channels or is absorbed by the soil. As more rain falls at these times of the year than at any others in certain latitudes, it follows that there is a greater weight of water in the soil, and a greater denudation or erosion of subterranean channels at that time of the year; and, consequently, there are two reasons for an excess of falls or landslips at this season. There are, however, earthquakes at all times of the year; and, as the merchant is unable to calculate on the last pound weight that kills his camel, so it is impossible to tell what immediate cause may tend to bring down many millions of tons of earth into the cavity that

may have been long yawning to receive it. Sand will sink when it is dry, limestone when it is wet; and, as many of these great earthquakes occur between mountains and the sea, where the slope of the hard mountain formation is carried on under water, we may easily imagine that such great earthquakes on the Pacific coast of America may be due to the subsidences which may arise on such a situation, with exactly the results of upheaval as I have quoted in the preceding section.

Place of earthquakes.

On looking at the regions where earthquakes prevail, I find them in the valleys of the great rivers (such as the Mississippi and the Ganges), on the confines of the ocean, on continents, and islands. In some of the latter there is an exceptional cause of earthquake action. Where the substructure is of coral, and the superstructure of stratified earth, the weight of the latter overpowers the water-worn support, and all falls down together, the extent of the shock being ruled by the size of the displacement. On the sea-shore, and in the great valleys, certain substrata are peculiarly liable to denudations by water; they contain the light materials deposited by tides and rivers; the percolating water finds such beds an easy prey; there is no land

that cannot be more or less undermined; but the wonderful arrangements of nature in the construction of the earth in layers, in banks of hard and soft substances, merit more consideration than has been bestowed upon them. Great rivers produce great flats; great oceans produce great extents of shore of similar consistencies; and though in small regions small earthquakes may be felt, it is where the great ocean deposits have been latest left that they are felt in all their dreadful grandeur.

Having thus traced out the "when," the "where," and the "how" of the great first earthquake cause, we come to the second cause, which gives us a shock attended with two dangers—one the shock itself, the other the noxious vapours. These are earthquakes of volcanic regions; and, deriving their own origin from two phases of the great water action, they become themselves the promoters of the volcanic energy. Second cause.

To get to the root of these phenomena we must go back to those days mentioned in a previous chapter, upon which, more or less, all these phenomena depend—when the grass, the herb, and the tree grew spontaneously; when there were no beasts or fowls to consume, or man to waste them; Root.

when they were liable only to the atmospheric destructions and their ordinary decay. No one can say how long this state of things continued; but we know that, from this condition of the earth, the foundations of new dry lands were laid; we know that, as the vegetable substances and the surface *débris* are washed away into the river deltas and the oceans now, so must they have been carried down in all past time, since grass began to grow and streams to run. Some of the results of these growths and workings are shown to us in our deep coal-pits.

Imagination may revel in a wilderness of reeds, bushes, and trees; but, accustomed as we are to the cultivated systems of civilization, we find a difficulty in comprehending the vast supplies of a bountiful nature. To enable my reader to understand this bounty, as well as the transporting causes, I will borrow a few words from Page, who, under the head of "Fluviatile Accumulations," describes the labour of the Mississippi in the formation of its delta. "The whole alluvial formation, from the base of its delta upwards, slopes with a very gentle inclination" . . . . "of about 200 feet in a distance of 800 miles." This deposit consists

Natural supplies of earth.

Carried by water for time unknown.

of mud and sand, with much vegetable matter intermixed, as "may be inferred from the abundance of drift trees floated down every summer, and which form tangled miscellaneous rafts, sometimes, like that of 1816, no less than 10 miles in length, 220 yards wide, and 8 feet deep." I would not venture on any limit of time during which such, and far greater, supplies of vegetable matter must have been carried yearly to the sea; but in the inaugural address of Dr. Hooker to the British Association at Norwich, in 1868, 600,000,000 of years were talked of as the age of the earth. Though this calculation may be far below the mark, yet it leads us into an incomprehensible quantity of matter produced upon the earth, and washed into the sea by every river that ever ran into it.

The great ocean currents conveyed all such matter as fell to their share into those regions where counter currents of wind and water created back waters and eddies. In these places the *débris* of the vegetable world was deposited, and in these places we find our coal. Page tells us that "in some fields as many as sixty seams occur, varying in thickness from a few inches to 4, 6, 8, 10, 12, and 20 feet." This is the first phase of water action Deposited.

necessary to produce the volcanic earthquake. Before it comes again under water influence, the matter thus lodged by the water has to undergo another ordeal. We have been told that the whole carboniferous period was one of "intense igneous activity;" and, as we find our hayricks, under certain conditions, are subject to similar action, we may assume that all vegetable accumulations have been from all time liable to the same.

Heating. Wherever, then, a mass of vegetable matter was deposited, there ensued a heating according to the size and condition of the mass. As this heating acted on the earthy substances buried with or

Refinement. around this vegetable *débris*, these earthy substances become metamorphosed and refined. In this process the metallic alkalies were produced according to the character of matter in the deposit. In all parts of the world this ordeal has been perpetually going on (a familiar example of which we see in our lime-

Example. kilns), and having produced this condition in certain places, we come to the second phase of water action.

This may be called the chemical process, and the slacking of lime gives us a sample of the action. Page tells us "the metallic bases of the

alkalies and earth, the moment they come in contact with water, are decomposed with an evolution of intense heat." We have been told how slowly, but surely, water percolates the earth, and while doing so it necessarily falls in with these alkaline preparations. According to the condition and extent of the mass are the results. It may be noted here that, as no two forces are the same, and as no two spots on which these forces act are similar in character or condition, it follows that no two phenomena of the same name can be similar either at the same or in different places. This is simply and easily exemplified in hot springs and mud eruptions. The latter are generally of a spasmodic character, because the force depends on the accidental accession of heat; the former are frequently like ordinary gushing streams, the liquidity of the affected matter enabling it to find its level without force, though occasionally, as in Iceland, the ordinary channels of egress being closed, the waters are forcibly and spasmodically ejected by a varying force. Here we fall in again with the working of water for the ordinary earthquake. Large extents of country may fall and be convulsed without the emission of vapour, the explosion of gases, or the

Waters meet alkalies.

issuing of fire; but here and there, in the same area, fire, gas, and vapour find a vent, as they did in the Lisbon catastrophe. It was on these sites that the broken earth contained materials ready to cause heat on their contact with water; and thus, when these materials fell down in the general ruin to the water which had caused their fall, they were immediately "decomposed," as Page tells us. According, then, to the condition of the inflammable materials, and according to the nature of the matter around, are the results of these contacts. Rumbling noises, explosions, convulsions, earthquakes, eruptions, are all dependent upon their sources. The vapours that poisoned Pliny the elder came from a plentiful source, as did the eruption that overcame Pompeii; while the terrible earthquakes in Peru and Ecuador of 1868 tell of the vast preparations that nature had there made for the exhibition of her destructive powers. In two minutes of time 20,000 human lives were lost, several cities were levelled to the ground, ships were wrecked and thrown high upon the shore, and the tops of lofty mountains were shaken and shattered into ruin. "It appears," says the *Quarterly*, "that the usual precursors were noticed—subterranean noises and slight tre-

Results.

mors;" but there was no escape—the sea came upon the doomed inhabitants from one side; the earth opened on the other; and, says the *Quarterly*, "the terrible wave which was seen from Arica to roll in and strike the mole to pieces, came probably from a line in the sea parallel to the coast where the most violent subterranean disturbance happened." This entire action is pictured to us in England by the landslip at Folkestone. This is of a few hundred yards, that of hundreds of miles; the effect is the same—a ruptured land, and a parallel disturbance in the sea.

Comparative effects.

It would be easy to multiply examples of earthquake destruction, but they would be of no further use in illustrating the great principle of their origin. I have briefly sketched the workings of nature as I understand them, and as I believe in them. I may have left some gaps in my arguments, which others may fill up; but, without the aid of an unknown internal fire, I have fully accounted for the origin of two kinds of earthquake. The causes are patent to all. Anyone who pleases can apply the principle, and find out the depth and extent of any earthquake movement. Intricate and careful experiments have been made with these intentions; but, after all,

Earthquakes accounted for.

Their depth various, depending on water run.

the real depth of the movement is the water-run which caused it. There is no escape from this conclusion. If the cause of the shock was deeper, the water would, as I have before said, run down; as it is, it runs up, and sometimes forms lakes where towns have stood. This phenomenon is due to the fall of earth into the water basin.

Having so far explained the causes of earthquakes, I go on to another phenomenon in nature, brought about by the same force, but attributed by many to a far different cause.

CHAPTER VI.

SUPPOSED IGNEOUS PHENOMENA.

THERE are many things upon this earth, and within it, which have been put down to igneous action, because the finders of them knew no other method of accounting for them; and then these phenomena are used as evidence to support the great theory of internal inherent fires of the earth. I find an illustration of one of these supposed phenomena in Page, p. 65, and copy it, as Fig. 1, quoting the passage referring to it:—"The fissures and fractures produced in the rocky crust by volcanic agency are known by such terms as 'faults,' 'slips,' 'hitches,' &c.; and when filled up by injections or infiltration of mineral matter, they are spoken of as 'dykes,' 'lodes,' 'veins,' &c. In the annexed diagram, A represents a single slip or hitch, where

Theory of igneous rock.

one portion of the strata appears to have slipped down, while another has been hitched up; B represents a fault where the strata are not only displaced, but thrown up at different angles; C a dyke where the fissure has been filled with igneous matter in the form of a dyke or wall; and D a suite of lodes or veins passing through unstratified and partly through stratified rocks." Page goes on to tell us that these displacements are called "dislocations;" "and just in the manner and direction in which the volcanic force exerts itself, so will these dislocations be few or numerous, simple or complicated."

Interpretations of laws.

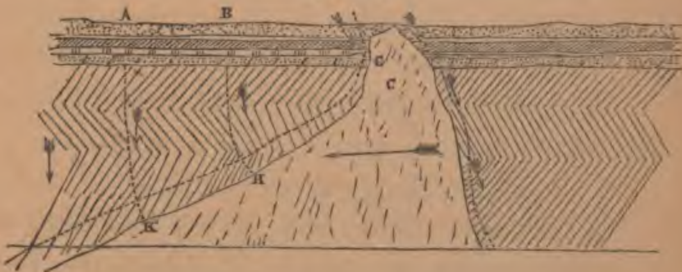
I am not at all astonished at igneous agency having been called in to account for the phenomena exhibited in this diagram. It is an agent of unknown power and of irresponsible action, to which may indeed be assigned many things in the absence of any other way of accounting for them; but nature has a great variety of laws, and their effects, which we as yet but very imperfectly comprehend, including the phenomena exhibited in this diagram, are capable of a very different interpretation to that which Page has put upon them.

The sketch shows a variety of stratified rocks

FIG. I.

Letter E, and the figures 1, 2, 3, are our own to illustrate the text

FIG. 2.



Probable original condition of the surface, and of the rock C underground, the arrows showing the line of subsidence produced by such a configuration down below; the dotted lines above the rock, showing the line of water, flows down the rock surface, and consequently the line of erosion on the softest substance—leading, in course of time, to a change from the horizontal to a vertical position of the strata, which formed over the steep side of the rock—and leading to the slips and faults on the sloping side. This explanation fully accounts for "outliers," and other displacements of strata, which have hitherto been attributed to volcanic causes.

Sketch. which are supposed to have been dislocated by the eruption through them of the unstratified rock, C, an igneous matter. Whenever one hard substance is forced through another, the external orifice of the latter opens outwards all round. In the case before us one side of the opening is outward, while the other side turns inward; consequently, this orifice was not made forcibly from within. If the dyke, C, was forced up in a heated and soft condition, through opposing rocks and earth, it could not have retained its present shape, as it must have been flattened or rounded. For these reasons I deny that there is any proof that the rock, C, was ever forced up by volcanic agency.

Rock not of igneous origin.

I will now refer my reader to Fig. 2, in which I have continued the lines of C, according to the shapes of the surface lines, which invariably indicate the character of that which is below. I have drawn these surface lines in the shape they assumed before the dislocation took place. As in the ordinary formation of the earth all the materials that are underneath were of necessity there before anything rested upon them, I will say that this rock, C, was in its place before the stratified masses rested on it. Under the head of "Hot Springs" I have

fully described the working powers of subterranean streams; exactly in the same way has water acted upon the mass under consideration. The rock, C, may be considered the harder substance upon which the percolating water ran while it wore away the softer strata that rested on it. When the upper materials rest upon an even bed, any occasional subsidence is level; but when erosion takes place on an uneven bottom, any subsidence necessarily follows the sinuosities of that bottom; and, consequently, if the sinking takes place in a tenacious or hard stratum, it follows that there will be surface cracks or slips to correspond with the inequalities below, and consequently the masses represented by A, B, in Figs. 1 and 2, have, in sinking to the face of the rock, C, ruptured the surface, as shown in Fig 1, the depositions having taken place on the lines represented by the small arrows in Fig. 2: thus the mass between B and the rock, C, subsided towards G, H, while that between B and A fell towards K, H. Explanation.

The action of the water on the other side of the rock, C, has had quite a different effect on the over-laying strata. This has been caused by the water running down the face of the nearly perpendicular rock, and constantly eroding the edges of the

Explanation. strata which rested against it. The result is shown in the falling in of those edges to fill up the vacant place; and in this manner we find, all over the world, masses which, once occupying a horizontal position, now occupy a vertical. I do not say that volcanic action has never produced such changes; but as I have seen them in situations where no igneous action ever existed, I may safely say that what can be done by water in one place may be in another; and, as the ejection of the rock, C, as placed before us by Page, is a simple impossibility, there remains no other force at our disposal but water to produce the effects pictured for us.

I will now shortly consider the character of the rock, C. I have already refused to accept its igneous origin in reference to its present position; and, from its general aspect, I come to the conclusion that it is also a water deposit. It will be seen, by-and-by, that water is capable of depositing unsratified substances, and these assume the shape of crag and tail from a very ordinary mechanical cause. In all rivers there are floods, and these wash down vast quantities of material, some of which is ready to assume a stonelike condition on the first opportunity. The flood, extending far

beyond the ordinary confines of the stream, deposits on all its borders boulders and other obstructions. No sooner do any of these become stationary than a sediment of some sort forms under the lee side, and rises in proportion to the protection afforded it. This sediment, adhering closely to the protecting object, assumes its shape on one side—generally perpendicular and abrupt—which may be called the "crag;" while the other end shelves off by the wash of the stream into a condition which may be called the "tail." As the rock, C, answers exactly to the shape of many such deposits which I have seen, I come to the conclusion that it was not an igneous dyke, but a water deposit, the current of water running in the direction of the large arrow in Fig. 2, the original support having been long since removed.

Having thus disposed of a portion of the diagram given to us by Page, I will proceed with the other portion, which embraces a question of deeper moment to the geologist than the other. We have before us the unstratified rock, E, and the stratified rocks, D. Through both of these rocks metallic veins have found their way. It is supposed that E is an igneous rock, and, after becoming hardened, Metallic veins.

heory. it became cracked and fissured. Into these cracks and fissures metallic matter has been injected. As this metal has run through the rock, E, into D, we may suppose that, under the system suggested, the cracks and fissures must have been made through ifficulties. both rocks at the same time. There are, however, serious mechanical difficulties in the way of this action. The unstratified rock is harder than the stratified rock, as proved by the greater erosion of the other. The hard rock is fissured into several fragments, any one of which would allow the entrance of an injection by volcanic force; but instead of seeking a refuge in the channels open to it, the supposed injected matter has found a way into the neighbouring mass, which could not have been fractured by any force which fractured the other, while there were other escapes from it—1, 2, 3, Fig. 1. As, then, the metallic veins have found their way from one rock to another, the question is—How did it happen? Page tells us to remember that, where an earthquake or volcanic shock "is accompanied by igneous discharges, the molten matter will force itself through;" and where the "rents are subsequently filled up by infiltrations of mineral and metallic matter, the result will be lodes and veins passing

through unstratified and partly through stratified rocks." When these rocks have been neighbours for any time, exposed to the atmospheric influences, there must be a percolation of water between them. The diagram in the present instance shows that there has been an erosion and a subsidence. How, then, could the force that cracked one rock crack the other? But, supposing it could do so, why should an infiltration of matter select those cracks to fill up rather than the more open space of erosion which must necessarily exist between two such rocks? The question is unanswerable. But there is a still greater difficulty in this fissure system. No fissure or rent could well take place unless the material was hard and brittle. How, then, could the metallic matter come through these hard rocks by "infiltration?" There is only one issue to these points—there was no infiltration into rents, because no rents were made; and, consequently, the whole theory of volcanic action, in as far as it relates to the deposit of metallic lodes in the manner suggested, is utterly unsupported. Explanation.

How, then, did these metallic lodes find their way into the two rocks? This subject is lightly sketched in my "Circle of Light, or Dhawalegeri;"

but, to enable the reader to understand the system, he must recollect that where these metals are now found was at one time under water. While in this state, all the sediments were composed of matter once held in solution. Of all these materials the metals were the heaviest, and consequently sunk to the bottom; and as water has the art of gathering into one place materials of one weight, it followed that the metallic matters were collected here and there into their little reservoirs. In these places they retained their plastic and ductile conditions till a harder, a more extensive, and consequently a heavier mass settled upon them, and forced them up through the settling material. There was no necessity for rent or fissure: the weight above and the plastic mass below were all the mechanical appliances necessary to lead the metal upwards through the softest places it could find. That all this was done under water I prove by the diagram before us. While the two rocks were covered there was no denudation, and consequently no separation between the two; there was a universal softness, into which these metallic lodes were gradually pressed by the general sinking of the superior mass *upon them*; there was, therefore, no channel

Explanation.

between the two rocks into which this growing matter could find a passage; but as it came out of a mass of one material, it necessarily passed on into the next. As the dry land gradually displaced the water, all these materials became hard and firm, the effects of the atmosphere began to be felt, the stratified rocks began to subside under its influence, and the metallic lodes were obliged to bend with the line of subsidence, as Page has placed them before us.

This principle is evident in the lodes of several metals—the strata in which they are found have slipped either by volcanic, earthquake, subsiding, or contracting causes, and the metallic lodes have slipped with them, remaining in the situations where first placed. If they were placed there by infiltration, there is no reason why that system should be stopped—but it is stopped; otherwise the metallic lodes would run down through the fissures of the faults and dislocations. As I have proved in several places that these dislocations are not necessarily due to volcanic action, and as there is no proof that metallic lodes in rocks are due to such action, but, on the contrary, as there is a *prima facie* evidence that they are due to the action of water, we may Principle.

No evidence of volcanic or igneous origin.

safely conclude that, although I am not in a position to give all the details of the transfer of metal into the body of firm consolidated masses of rock, yet that there is no trustworthy evidence of the phenomenon coming under the igneous causes; and, therefore, that the whole subject requires a plainer and more correct explanation than Page gives us.

Having so far found that water can readily account for many of the phenomena of earth which have hitherto been attributed to fire, I propose to inquire briefly as to water formation and fire reconstruction. They are great subjects, and much more is involved in them than I have the means or the time of investigating; but as the arguments I shall bring forward in favour of water are founded upon personal experience, and are not produced without consideration, I feel that, however imperfect they may be, they will yet contain truths which may lead others to a fuller comprehension of the wondrous theme.

CHAPTER VII.

FORMATION—WATER.

THE question, then, is, What portion of the earth is due to fire, and what to water? In those which are called the "primary strata" there are no traces of organic forms. It has been said that this proves that there was a time when no life existed on this globe. By this term, "no life," we understand that no animal of any sort or kind, in air, water, or on land, existed. We make exception to the germ of life, because no one could say that it did not exist; and as its existence is an invisibility, no assertion can be made regarding it. In the most beautiful forms and the most extraordinary combinations of organic bodies we find the same materials that we find in a granite rock. Lime and silex pervade all nature. The granite rock can be

By water or fire.

converted into dust, and portions of every living creature come to the same end. The germ of life floats in the liquid of an egg, whether it be of bird, fish, or reptile. The germ of all life is sustained in liquid. From these liquids are formed the whalebone, the ivory, the ostrich plumes, the fish fins, and all the wondrous changes which we see in the existence around us. We can analyse the composition of every organic substance, but we have not yet succeeded in analysing life. We will, then, leave life out of the question, and pursue the subject of organic formation.

rganic formation.

Omnia ex ovo, may be carried on; and as within the shell all the gases and the liquids necessary to form the organism are contained, so within the atmosphere and water all the liquids, gases, and materials are contained necessary to form the earth. With the exception of life, the earth and the organisms are the same in composition. There is no substance of the latter that cannot be found in the former, though there are substances in the earth which have not been detected in organisms. The growth of the germ into an organism is a mystery, and the growth of the earth is under the same cloud. Astronomers have found in the

heavens luminous films which they have supposed to be worlds in the process of condensation. Philosophers have maintained that this earth was once in a nebulous state. We know that solid substances become volatilized and invisible to the human eye, and that, under certain conditions, they again become tangible bodies. By a very simple and clear analogy, then, the earth and its organisms may have been produced in the same manner from gases and liquids. Analogy.

We will endeavour to pursue this analogy through the vegetable world. The germ of the seed requires moisture to enable it to germinate. As germination is produced, the root descends to gather nourishment from the earth, and the leaf expands to gather gases from the air. From the air and the earth are gathered the ingredients which made the nettle, or the palm-tree, our foods, and our poisons. We have only to cast our eyes upon nature, and we find that no two plants which grow are similar—the variety is infinite, yet all come from gases and from liquids. Vegetable formation.

The vegetable world retains in itself the hydrogen and carbon that it gathers by root and leaf, while it discharges oxygen and azote gases. The animal

world retains the azote and oxygen, but discharges its carbon and hydrogen. There is, then, a perpetual circulation of gases between the animal and vegetable worlds, and these great worlds may be considered as parts of a greater world, which by its mysterious and wonderful affinities produces, under one great Ruler, every variety of vegetable and animal life out of itself; and, as like begets like, so the earth, under the influence of the gases and the liquids, reproduces itself. Everything that ever lived, animal or vegetable, returned its dust to the earth, and its gases to the air, unless causes which we have above described imprisoned the gas and the substance. While the animal or vegetable is in life, its gases are necessary to its functions; when they die the gases resume their places in the atmosphere. There is but little delay in either case when the dead substances are left to decompose in the air. As the animal is liable to quick decay, its gases escape rapidly; but as the vegetables (such as the great timber tree) are hard and firm in their composition, the decay is not so rapid, and this slowness of decomposition gives nature time to carry out other arrangements for one great end.

Dust to earth—Gas to air.

That end is the point we are endeavouring to arrive at; and having, as we believe, shown that the world owes its origin to liquids, gases, and matter, we must go on with the systems and the laws which this origin brought into operation. Everything that has an existence on the earth grows outwardly, the growth being caused by that which is taken inwardly. We believe that this world has grown by the same law. There is a perpetual give and take all through nature—the organisms live upon the produce of the earth, or water, and in turn contribute to the growth of the earth. There are thousands of minute animals in the surface-soil which give their little bodies to the great work; but the organisms of water have been most minutely described, because, as they are buried and preserved by this element, owing to the sediment deposited with them, they can be examined with facility. D'Orbigny found "3,840,000" shells of foraminifera in an ounce of sand from the Antilles; the bed of the Gulf Stream contains "diatoms" and other minute animals through its whole course; the Gulf of Mexico is full of organically formed marls;—all "indicating a formation in process as gigantic as any that

Law of Growth.

zoology has yet revealed, and yet dependent upon forces apparently the most trivial and insignificant in nature" (Page, p. 329). If these minute organisms have done so much, we may imagine what has been done by the larger. Our geologists have as yet scarcely comprehended the vastness of their contributions. We come across the secret of nature every now and then in a discovery of caverns full of bones. We see daily before our eyes vast masses of limestone rock; but it has never struck any geologist or zoologist that these rocks are entirely formed from the triturated contributions of organic bodies, and that their unbroken bodies and their undecomposed bones helped to form the nucleus over which the decomposed, triturated, and liquefied shells, bones, &c., formed the hermetically sealed cave which has preserved them so long that there is no history of the period of their existence (see "New Pages of Natural History," Newby).

Evidence of Formation.

Page has divided the natural accumulations on the surface of the earth into "fluviatile, lacustrine, marine, chemical, igneous, and organic." We will place them in two divisions—animal and vegetable. There are no other accumulations on the surface-earth except from these. We will allow that

they assume as many variations in their dead condition as they did in their existence. We cannot recognise the diatoms in the mass of flint, or each individual shell or bone in every limestone rock; yet each made portions of the compost, and here they are on the surface-earth as lasting monuments of the unknown organisms which made them. How did that surface grow?

We have in other chapters sufficiently explained the vast accumulations of vegetable matter. It now remains to show how this has been distributed all round the world. Our geologists have told us that we are very ignorant regarding the currents of the ocean. This ignorance has hitherto prevented their giving that credit to ocean labours which I now propose to do, for we believe that the ignorance arises only from the inability to put things together. In the great puzzle of the subject the attempts have been made on too small a scale. We will borrow a sample from Page (p. 292-3) to explain what we mean:—"Most of the hills, as in Britain, present a bare, bold, craggy face to the west and south-west, as if worn and denuded by water; while their slopes to the east and south-east are usually masked with thick accumulations of

Distribution of matter.

clay, sand, and gravel." This character of country is, he tells us, "known by the name of 'crag and tail;'" and after a description of the working of currents, he writes:—"It is evident that in Britain the transporting currents passed from north and west to south and east." We will use this fact as a proof that the present aspect of the earth offers evidence of the forces used in its building, and that, wherever we find one side of a mountain precipitous and scarped, the other side extends in a gradual slope; the whole assuming the character of crag and tail, a character which anyone may read in the sand ripples of the sea shore; we know at once that the same agencies produced these effects as produced or shaped the hills alluded to by Page. The abrupt side is the side upon which the building force was applied.

Law of Deposit in America.

On looking at the earth, we can, by these formations of the mountains, trace the systems of currents which formed its present surface. We find upon it three great centres, and one long line of original primæval mounds, every one of which tell us, as plainly as if we witnessed their conformation, how that came about. The back-bone of America, being *precipitous* towards the west, and sloping to the

east, was formed by currents of wind and water, which in their yearly changes continued principally from the west to the east. The character of the currents which formed this great range of highlands has not changed from those to the present days, and the regular lines with which the founda- Proved by aspect. tions were first deposited show that the wind and water currents of the great Pacific Ocean were as regular then as they are now. There is a law of nature in thus laying down its formations which may be shortly exemplified here. Wherever the hills have assumed the shape of "crag and tail," the rainfall pours over the hard precipitous side with a strong superficial erosive effect; but on the sloping, soft side, composed of all the lighter materials which subsided under the lee side of the original bank, the rainfall is absorbed or runs off with a steady denudating process, so that the original character of the formation tends materially to its own extension; for as the erosion goes on, the material is perpetually washing downwards and increasing the slope. From this law of nature we come to the grand result—that the largest rivers And rivers. on the earth flow from the lee side of the hills in which they have their source.

The three great centres of formation on the earth are the Alps in Europe, the Nepaul Mountains in Asia, and the Mountains of the Moon in Africa. From what we know of the latter we may assume that the crag side of these mountains looks towards the east and south-east, while the Nile and the Niger show us where the original tail of the formation, allowing the rain to fall off gradually, contributed materials for the construction of the valley of the Nile and the forest-growing shores of the Niger, &c. There is also a proof in this region that the winds were more violent than in America, for they have blown from the mountain tops and slopes all those great sand deserts upon which no verdure grows and rain but seldom falls. The illustrations of the erosion on the crag side of mountains were beautifully given to the world by the *Illustrated News* during the campaign of 1868 in Abyssinia, and we can trace back by these pictures that while on this side the rainfall has worn away the great ravines or cuttings in the hard rock for a distance of a few miles, we have on the sloping side in the valley of the Nile a fertile extent of some 1,200 miles in length, which is allowed to be the creation of the river during the same period.

The same in Africa.

When we come to consider the formation of the mountains in Central Asia, we find that their situation was the scene of contest between the north-east and south-west currents of wind and water. The consequence is, that there is no "crag and tail," in the ordinary acceptation of the term, though here and there it is remarkable in the Himalaya range. The result of this is, that great rivers rise on either side. The Indus collects its waters from the north and south; the Ganges from the south-east end of the range; while the winding Sampoo (River Snake) gathers its floods from the north and the east. There is another proof of the great contest which raged between winds and waters in these regions, for no sooner were the north-east winds and tides baffled here than they met with the westerly currents, and formed the great chain of the Ural; and while they were thus engaged the south and easterly currents came up, and helped to form the vast chain of the Altai, extending from the Thibet mountains to Bhering's Straits. The rivers Lena and Ob show us that the north currents were here overcome, while the Amur and Hoanho tell us of a contrary termination of the contest in the same long mountain range. Continuing to

Asia.

Formed by contesting currents.

fight over the disputed territory, we find that the north-east forces were effective along the coast of Abyssinia, while the south-west currents built up the mountains which run down the western coast of India.

Europe the same.

Looking over the surface of Europe we find that a contest similar to that of Central Asia took place in the district now called Switzerland, and constructed the irregular mountains called the Alps. The contest here was on a smaller scale than that in Asia; but after the great banks which now form the Alpine regions grew high enough to obstruct the water currents, these, being diverted from their normal channels, laid the foundations of the hills in Turkey in Europe, the Apennines, and the Pyrenees. Although the Alpine ranges appear intricate and confused, we can find their analogies in every mud bank in a tide-way. Where tides and winds and ocean meet with river currents, the surface is cut up into thousands of mounds and hollows; there are firm spots and soft ones, over and through which the waters trickle off by their numerous channels. These little channels tell us of the original surface character of the now lofty Alps. Thé firm places are represented by the

highest peaks, and the soft places are worn away into the beautiful and winding vales. Millions of years ago the Danube, the Rhine, and the Rhone trickled down the gentle slopes, and they have continued their labours from those times till now, forming in the meantime the fertile valleys through which they run and the deep gorges in the mountains which delight the lovers of the picturesque, few of whom think of the "when" or the "how" the hand of nature was carving out these stupendous precipices. As the ocean currents were compelled, by the growth of dry land, to alter their courses, the results began to assimilate to those of Asia. The Carpathian mountains may be likened to the Altai, and the Kalen mountains of Norway to the Ural. From all these high lands the waters flowed and worked from the moment that rain first fell upon the surfaces; and as the duration of time has been calculated for the construction of its valley by a portion of the Mississippi, so also the age of the valleys might be calculated which we now find embracing the Volga, Dnieper, Vistula, and Elbe.

Our knowledge of the interior of Australia is as yet too small for us to enter into any description of **Australia unknown.**

the river sources of that region; but the laws are the same there as elsewhere; and we shall come presently to some of the results of those laws. It will be seen from what has been said that the high lands in every portion of the earth have rivers running from them.

Rivers run from high lands.

Erosion.

We will now refer to Page, as the best authority at hand to continue the history (p. 303):—"The natural tendency of rivers being thus to deepen their channels and spread the eroded matter over the lower levels, all river valleys will, in course of time, become dry plains, even though originally consisting of marshes and chains of lakes." "Such operations have been going on since the land received its present configuration;" or, in other words, every mile of valley from the hill-tops to the seas has been formed by the erosion of the higher lands and the filling up of the lower. This erosion includes everything that ever grew on the surface as well as that which the force of the water was able to wash away from the interior; consequently (p. 304), "in course of time, these deposits constitute large expanses of low alluvial land known as 'deltas.'" Reasoning backwards, the delta is formed of the latest deposits and the

higher valley of the earliest. This latter tells of the eroded rock from the mountain side, worked up into boulders, shingle, gravel, and sand; while the delta exhibits all the latest burials from land and water, so that, as Page tells us, "We have thus a complex set of agents—rivers, tides, waves, the drift from inland, the drift from the sea, and the growth of plants and animals *in situ*." "By insensible degrees we descend the stream of time from the eocene paleotherium to the pleistocene mastodon, and from the mastodon to the present day, when the silts entomb the remains of buffaloes, bears, wolves, racoons, opossums, otters, minks, beavers, and other creatures now peopling the American continent. As with the delta of the Mississippi, so with all others, making allowance for the region, climate, and biological provinces with which they are connected" (p. 309). So it has been **Deposits.** from all time—the vegetable and the animal have been buried entire or in fragments. The remains which we find in our caves were once resting in soft silt till the lime sediment settled above them, and formed those coverings which have preserved the remains for many thousands of years ("New Pages of Natural History").

At the bottom of sea, where heat is not.

It must be recollected that all these deposits of every kind took place on the then bottom of the water, a place which, under ordinary circumstances, possesses no inherent heat. These deposits are found in our present vales and in our mountains, and we have no reason to suppose that a deposit of any sort could by any possibility create a heat in the rocks below it, these rocks having previously been cold. All heat rises, so that any heat which exhales from the sides or bottoms of our deep mines may naturally arise from the deposited materials, and only have a local effect. "Vesuvius" (p. 322) tells us that "the theory of volcanoes has been approached from various points of view, but not fully reached by any one of them." We believe that we have sufficiently proved that every theory hitherto suggested is in error. Phillips has brought his source of heat under each volcano, and Mr. David Forbes is not prepared to attribute the rising of lava solely to contraction of rocks. Our road is therefore becoming an open one. We have traced a water formation all round the world. No one can pull down the sign-posts we have used. They can be seen in every tide-way, and in every region raised by the contending elements, past and present;

Water formation proved by land marks

they are of every stature, from the mountain five miles in height to the little sand ripple on the sea shore. There is no escape from the conclusion that, as the mud banks and sand hills are made to-day, so were they made of old ; as vegetation grows and dies now, so did it of old ; as its refuse is washed away now, so was it then ; as the waters gather the waifs and strays now, so did they through all time ; and it only remains to connect the vegetable deposits of old with our extinct and active volcanoes of the present to show what alterations fire has effected on these water formations of our earth.

CHAPTER VIII.

FIRE.

WHEN I come to consider what fire has done upon earth, I find before me a confused and intricate subject, with so wide a field that I am obliged to reduce it to such an outline as may enable the reader to comprehend, not only the universality of the principle, but the truth of the system which I offer to him.

Outline of results to be traced.

We have been told by Page (p. 54) that water and fire "may be considered as antagonistic to each other, and to them may be ascribed the principal modifications that have taken place, or are still taking place, in the crust of the globe." I do not propose to enter into these modifications in detail. I shall be content to mention the chief places all round the world in which the action of fire is con-

spicuous, and to trace back from the effects their connection with the great causes mentioned in the last chapter.

In our daily experience there is a species of antagonism between fire and water; but in the vast system I am describing, I allow no original antagonism between them. This earth was massed into its first rough condition out of chaos by the forces of the atmosphere and water. I have shown how nature produced, and how its productions died; I have described the natural effects of denudation, and the great system of conveyance and deposit; I have exemplified the results of these deposits by showing how their gases and their heat converted the buried materials into varied chemical changes and altered conditions, and how again water has acted upon these with results varying with every condition; I have sufficiently described how every volcanic phenomenon is produced by the nature and quality of the imprisoned gases, assisted by the nature of the locality where they are imprisoned. As the matter thrown up by these eruptions is composed of materials deposited by water above those which contain the igneous gases, the alkalies, or other causes of heat, it follows that, as

Fire and Water not antagonists.

this erupted matter was in its original state resting over and upon the heating cause, if this cause was deposited by water, then all that ever rested upon it was either placed there by water or grew upon it as an ordinary production of the earth. Under either condition it became liable to the forces working from below; so that I say, instead of showing any antagonism, water and fire have worked in the greatest, the most wonderful harmony in bringing this beautiful world into its present condition. I go, however, a step further in reference to fire, and say that, instead of being a foe to, it is a dependent on, air and water; for as all the produce of this earth, animal or vegetable, is dependent on these two elements, so without these productions we should have no fire. There would be nothing to maintain it, nothing for it to act upon. Fire, therefore, having no existence of itself, is in fact an effect of something else; and though it is a cause of other changes, yet in going back to primary causes I cannot accept fire as one of them.

I may be able to give a clearer view of my meaning by an illustration from "Vesuvius," p. 324:—"An interior fluid composed of silicated

earths, alkalies, and metals accessible to water, and open or capable of being opened to the air or the ocean, is the fundamental condition of volcanic excitement." Here Mr. Phillips is very near the truth; but, as usual, he runs away from it by saying, "That this fluidity is due to the inherent heat of the earth may be regarded as a settled point." This author has his interior fluid all ready at a depth of twenty or twenty-two miles, and here, he tells us, "must be, if not a general mass of internal fluid rock, at least a limited tract of subterranean lava ready to ascend on the application of adequate pressure" (p. 262). He has previously told us, at page 261, that "this pressure on the lava may be exercised by steam." He is not particular where this steam may be generated; neither is it of much consequence to the point in view. The steam could not be produced without heat. Heat is a result of the great laws of nature, and all things emanating from that result are also results of one great cause. There is a familiar example constantly before our eyes; the shell, the limestone, chalk, and other substances, being submitted to the heat of man's production, become converted masses. In this state they become cold; water

Exemplified.

also is cold; and both in their single separate conditions have within them no signs of fire. The moment the two come in contact heat is produced, the water is absorbed, gases are discharged, and another chemical change takes place in what was once the home of a fish, the liquefied remains of bones, or particles of foramenciferæ. Under the system I have described these changes may—nay, must—be of constant occurrence in the earth beneath us. I therefore accept heat and fire, with all their wonderful combinations, as undoubted effects of those great laws which I have shown have been in operation upon this globe from time unknown.

To make my subject more complete, I find it necessary here to say a few more words on the supposed internal fire of the earth. I have shown in Chapter IV. how far Professor Phillips may be trusted in his histories of ordinary earthly phenomena. He has a complete knowledge of the combinations of the alkalies and waters; he is fully acquainted with the beautiful calculations of of Mr. Mallet, who points out to him that volcanic excitements originate between five and eight miles from the surface of the earth; he knows that

Continuation of error.

certain deposits within the earth are full of gaseous matters;—yet he throws off the evident and natural result in favour of what he calls "a settled point," this point being a general belief in an internal fluidity of the earth, which no one has yet succeeded in harmonizing with nature. Notwithstanding this failure, the fashionable hypothesis is, up to date, constantly produced in the shape of lectures before future officers of our army at the Royal Military College, Sandhurst; the internal fire, the molten lava, the cooling crust, the contraction, the pressure, and the ejection through miles and miles of an utterly unknown substance, is submitted with all gravity to our wondering listeners. Page had the honesty to say that there was no geological proof of this theory. I say that our geologists have mistaken effects for causes, and that these are some of the greatest errors of the present day, which should be corrected as soon as possible.

Law of Nature.

The laws of nature are so grand, so magnificent, that I feel almost abashed at entering into the fire arena; yet the whole system is so simple that, in the face of an opposing science, I do not hesitate to declare it. The law of to-day was the law of

old. There has been no change in that, though there have been constant variations in the substances entrusted to these laws. At present the rains, the rivers, and the seas are occupied with the disposal of the refuse of a civilized world; before and since man appeared on the scene the same forces were busy with the carcases and the bones of the animal kingdom; while mixed up with the early portion of that great age, time was occupied in the disposal of the vast incomprehensible vegetable world. Page has told us (p. 304), "Many of these deposits are of vast extent; and with the exception of what is taking place in the bottom of the ocean (of which we know almost nothing), they are of all modern formations the most important in modifying the crust of the globe." Again the clue is missed, and Page goes on to tell us of the varied fluviatile and marine deposits. Thus, by endeavouring to turn all these labours into one groove, geology, natural history, and palæontology have hitherto shut themselves out of the vast fields which are for ever expanding before them in the vast, the unsearched mausoleums of the world.

Vegetable world, its carriage.

Wherever any igneous action is visible upon the

face of the earth, man may rest assured that old burials have taken place not far away. He will understand one phase of the action of these deposits by looking at a similar deposit, which, like the ghost without an obolus on the shores of the Styx, could get no decent burial, but which testifies openly to the great law of nature in the production of gases. Such an evidence is found in the great bog of Franzensbad, which exhales with its healing waters the air gathered by the vegetation when in life. The Lima *National*, of 13th May, 1869, gives another example in a gas jet that kills every beast which reaches a certain spot, so that "immense numbers of carcases are heaped upon it." Then we have the unhealthy shores of Jamaica, the Upas valley of Java, and nearly 1,800 years ago Pliny was killed by the rise of gases from the earth. Every region has its own peculiar history of gaseous and igneous causes: the valleys of the Indus, the Ganges, and the Mississippi have declared their tales; and in the deposits of river and of ocean it is not impossible that the history of the world may yet be read.

Its burial exemplified by surface deposits and gases.

The general features of this earth over which I now propose to trace these igneous actions, as

arising from the productions of the earth, may be defined by the mountains five miles in height, and the ocean five miles in depth; the one has for ever received the surplus of the other, and has used this surplus, mixed up with its own spoils, for the work of construction. Our coal was deposited where we find it at as many fathoms beneath the surface of the then sea as it now is below the tops of our highest hills. Over these coal deposits, and at varied spots of higher levels, we find the limestone, the slate, and the marble, all telling us in words as plain as the Bible that the animal life which contributed to these formations came after the great vegetable deposits. There are in America, China, Japan, and in many distinct places upon earth, far more extensive coal-fields than there are in England; and as some of these drifts have been brought here by ocean carriage, we may assume that the same carriage has been made use of in other parts. The mariner and the lighthouse guide the benighted ship into her long-sought home; but these drifts were carried by the ocean currents intent on building up; and we find upon the confines of ocean all round the world, with a few exceptions, the results of this great law of carriage and deposit.

Area of Nature's works all round the world.

In naming places at which present igneous action gives evidence of former gaseous or igneous deposits, I propose to follow Page (p. 113); but the source of the drift is my own. We are told that "in Europe there are three well-known centres of igneous action"—that of Italy, Iceland, and that of the Azores; in Asia, on the Levant, the Caspian, the Red Sea, and the Indian Ocean, through the Indian Archipelago, and through the Philippine, Japan, and Aleutian Islands; there are active volcanoes in the Antarctic Ocean; while in the Pacific, New Zealand, the Sandwich, and other island groups, are partly the results of volcanic action. In the Atlantic, the Canaries, Cape de Verd, Ascension, with other islands on the western coast of Africa, are seats of igneous action; while the American region includes the West Indies, and all the way from Terra del Fuego, through the Andes and Rocky Mountains to Alaska, are to be found some extinct, some smouldering, and some volcanoes in greater or less activity.

On looking at the formation of Italy and Sicily, there is no great difficulty in saying that the drift foundation of past and present volcanic action Europe.

came originally from the Alpine regions by the river Rhone; Etna, Vesuvius, and Stromboli owe their present celebrity to materials which either grew upon the slopes of the Swiss Alps or to those substances which underwent a chemical change from heat produced by those materials; Iceland received its foundation by the eddies of the Arctic Ocean falling in with those of the great ocean current, called the Gulf Stream, running from the Gulf of Mexico into northern latitudes. The amount of igneous force expended on past and present volcanoes shows the vast amount of material which has been buried here, and proves (if proof is wanting) that volcanic action is capable of consuming all the material placed at its disposal, and that in return for this vast consumption it throws up the sands, the lavas, the mud, and the silicious sinter, perpetually converting old material, and placing it, as a new and converted substance, once more at the disposal of the never-resting wave.

Passing on to the Levant and the Caspian region, we find that the wash of the Nile conveys to this day the produce of Central Africa in this direction; but the Nile has been a civilized river so long, its waters have been economized for so many

historical ages, that we may go back to a period long before those times, when it swept in its wildness over its growing delta from far above Thebes, over the site of Cairo, over the present Isthmus of Suez, and away to meet the currents of the Volga, the Dnieper, and the Danube. It is to these rivers, running over the tails of Northern Africa and Southern Europe, that the regions alluded to owe their igneous action. There are mountains enough on the confines of the Red Sea to give rise to volcanic forces by the water carriage running from them; but there may be, at the same time, other causes which have given rise to its volcanic character. The coral insect has laboured hard and long in these waters, islands have risen by their exertions, the burning winds and the great dust storms have soon given a canopy to such growths, while the wash of the passing wave, and the perch of the weary sea bird have raised the surface into an habitable spot. Then, as in all coral localities, decay and dilapidation come on, and the accompanying landslip or subsidence has often been put down to volcanic causes. Asia.

Looking for a moment at the Indian Ocean, we find a wide expanse of water comparatively Indian Ocean.

free from volcanic action. Perhaps Mauritius and Bourbon monopolise some of the igneous materials from the Euphrates or the sand-loaded Indus; but the greater portion of the produce of the Himalayas and the south side of the Thibet mountains was in all probability lodged on the western sides of the Malay Archipelago, extending from Sumatra to Bali or Timor, and joining there the collections from Australia, which serve as a connecting link between Celebes and the Philippine Islands. The foundations of gaseous and volcanic materials seem to have been laid over this vast region by winds and currents, similar to those of the present day, in the shallow seas, which hold Borneo as their great centre. For a more minute analysis of the original foundation of the igneous action of this region, I would refer my reader to the "Malay Archipelago," by Wallace.

China Seas. Passing on, we come to Formosa, upon which the waters are even now heaping up materials and blocking up its harbours; so that here we have an example of a constancy of currents, for the island is well supplied with igneous matter. All this was brought on from the high lands of Central Asia by the great rivers, which helped to form the Chinese

territory; and some of these passed their vegetable materials on, to lay foundations for volcanos in Japan and Kamtschatka, northwards of which the produce of Asia (coming down the Lena), and the produce of America (coming down the Mackenzie), found a passage through Bhering's Straits, and lodged as the igneous foundation of the Aleutian group and the promontory of Alaska.

Pacific and West Coast of America.

Looking down upon the wide Pacific, we see one of the grandest effects of volcanic force; and as no great rivers run into this ocean from the western coast of America, I may safely conclude that the origin of this force was brought on by ocean currents from Bhering's Straits or the China rivers. All along the coast of North and South America, from Alaska to Terra del Fuego, "are numerous volcanic rents in a state of greater or less activity." We may look to the Rocky Mountains, and the interminable Andes, as the growing place of all the material which has constructed so many and so great mountains, and which has filled the region with refined metals and minerals. As the currents run now upon this coast, so have they done in all times; and in doing so they have buried in the little estuaries and (all along the mountain range)

the vast collections of vegetable matter which could get no further for want of carriage. The river Colorado exposes this burial system, for by late accounts it appears to have cut through many thousand feet of stratified earth.

Antarctic.

Passing on to the Antarctic regions, we find several cases of active eruption caused by waifs and strays from the Pacific, the Indian, and the Atlantic Oceans. Into this great water some of the largest rivers in the world empty their luxuriant vegetation from the tropics. Who could measure the quantities of matter brought down to the sea by the rivers De la Plata, the Amazon, the Orinoco, the Mississippi, and the St. Lawrence? Who could tell into what currents they fell, or to what region they were wafted? I may ask the same questions of the productions of Central Africa brought down by the Congo, the Niger, and the Senegal; but each has, from time unknown, been engaged in a yearly traffic. Scattered over the face of the ocean are numerous volcanic islands, each acting as evidence of a vast accumulation of fire-producing material from these sources.

Atlantic.

There is no imagination in all this produce, in *the water* conveyance, or in the deposit. The latter

Result of collections.

is proved by its re-appearance in gas, in smoke, in flames, in eruptions. The water is occupied in the same manner up to this very hour in every portion of the globe, and on every bit of its surface there is still something to be blown or washed away. Wherever great collections are made, the igneous action of the carboniferous system takes place. The materials are refined and prepared till causes before detailed convert the substances once more into a moving mass. It is of no use here talking of the force exercised by these masses. This depends entirely on the quantity of material heated, the modifying causes which may be present with it, and the strength of the overlaying strata. Whatever these may be, the heat once evolved, and the gases liberated, no thickness and no strength can prevent an eruption of some sort or another. The gas will rush back to its kindred atmosphere, and the flames work back to the air from whence they came.

The very conformation of the earth proves the truth of this beautiful system. There are long coasts in the world upon which there are no volcanos; but it is on the confines of the sea and where waters have been that we find the past and

the present volcano; and while we find the currents of the ocean or the wash of the tides still depositing materials upon or near to the volcanic regions, it is fair to assume that they always did so. It would be marvellous if the imaginary central fires of the earth selected for their eruptions those very places upon which the natural force of the external elements was depositing its well-known igneous material from the great vegetable world; but as it is in these spots that volcanic action does take place, I look upon it as conclusive evidence against any eruptive force from the interior supposed furnace of the earth.

Proved by their issues and by their extinctions.

To this argument may be added the facts that many volcanos have become extinct, that volcanic earthquakes have ceased, that hot springs have become cool, that mud eruptions have ceased; showing that their existence depended entirely upon local and perishable causes, and not on one "vast accumulation" of molten matter within the earth. Thus has it been for unrecorded ages: the earlier deposits of Iceland have been long since used up; the old craters of Vesuvius, of Ararat, of Auvergne, and all around the world, contain the history of time. Their eruptions are left to us in

the shape of decomposing lava, of ashes, and in a multitude of rocks which have, through heat, changed their original character.

No analogy in nature for a fire creation.

If, then, the supposed internal fires of the earth have nothing to do with volcanic action, how much less are they concerned with the structure of the earth? There is no law for such a result in nature. We know of nothing analogous to it. The stars have been invoked to secure analogies, but nothing certain has been proved. Astronomers have told us that the nebulæ in the firmament are worlds forming under the influence of fire, and consequently that this earth was once in a similar state; but in nature no two things are similar, and consequently if the astronomers are right, they give no rule for the creation of any other world but the one selected by them. Fire has acted upon this earth as a destroyer, as a modifier, as a changer—never as a creator. It must have something to act upon, or there is no fire. The electric fluid flashes harmlessly from cloud to cloud, and only when it falls upon combustible or destructible materials upon earth is the effect of its heat known. We may call in physical magnetism according to the system of Dr. Stevenson Macadam, but the heat produced

Fire alters, but does not create.

has no effect on incombustible materials. No application of this heat without gases could eject lava from a melted rock; so that, as gases and heat are provided by my system, and as granite and basalt are melted and ejected as lava, there seems to be no escape from my conclusion.

Example of surface fire action in converting substances supposed to be of volcanic origin.

There are, however, other methods for the conversion of one substance to another by the action of fire than I have above described. I borrow a few lines from the *Student* of 1868, p. 279, to explain the case:—"Occasionally after a severe thunderstorm a rude lump of glass, formed from the fusion and vitrification of the silicious article and alkaline ingredients of the reed or thatch, are the only traces to show where a Kaffir hut had recently been standing." I have given an idea of the vast mass of material which must have been yearly washed down by every running stream upon earth, but everything which grew was neither washed or blown away. Year after year the reed plants, especially, grew again, and for uncounted years they continued to grow, nourished by their own decay. We look upon the strip of rushes on the banks of our economic streams; we look upon the bunch of Pampas grass standing in our little

garden ;—but we have to stretch our imagination to its extreme limit to see the vast accumulation of silicious matter beneath the old wilderness of reeds. In course of time the mass is deserted by the water, and becomes dry. It may be struck by lightning, or some other accident may ignite it, and the result might be a mound of glass, of porphyry, or obsidian, according to the materials fused together with the silicious substances. Thus there may be many objects on or near the surface-earth which, having now the character of volcanic productions, may be produced by surface-fires. They are of frequent occurrence in India, and the great prairies of America are sometimes in flames. Lavà is the only matter ejected now by volcanic action, no obsidian is produced, and I see no reason to suppose that, as it can be made in one way, it should be made in any other.

There is one more point that I must touch on before bringing the subject to a conclusion. It is one which has attracted the attention of our philosophers, though none of them have given a satisfactory interpretation of it. It has been remarked that the excitement of one is communicated to another volcano. There may be many causes to

ommunica- on between olcanic gions by mospheric auses.

produce the same result; the dryness or wetness of a season may have a similar effect on regions of the same consistency; the superincumbent weight may be no longer able to support itself over the subterranean denudation, and similar heating causes may be released by subsidencies;—but an accident revealed to me how much the upper atmosphere may affect the subterraneous air. Some years ago a well in my garden, about seventy feet in depth, required repair. After leaving it open for half an hour a candle was lowered, and a man descended. After working for some time a thunderstorm passed over, the candle in the well went out, and the man was drawn up inconvenienced by the foul air. Soon after the storm had passed over the man again went down, with the usual precaution, and finished the work in comfort. This occurred under my own eye, and I argued from the fact that, as volcanic excitements are frequently attended with thunderstorms, they act upon the pent-up gases of the inner earth as they pressed down the foul air within the well. Had Virgil any idea of this connection between the external and internal air when he wrote—

> "Hic vasto Rex Æolus antro
> Luctantes ventos, tempestatesque sonoras
> Imperio premit, ac vinclis et carcere frænat
> Illi indignantes magno cum murmure montis
> Circum claustra fremunt"?

They not only roared round the entrance, but they gained access to the interior; and a close observer of atmospheric changes, compared with the volcanic excitement, might derive such a knowledge of causes and effects as to obtain from his careless neighbours the same character which King Æolus gained from the ignorant inhabitants of the Æolian islands.

Cause of volcanic excitement local.

I hope that I have now satisfied the most sceptical that the source of volcanic excitement is local; that it depends upon chemical action brought about by the materials buried in the earth; that the origin of it is not necessarily deep, but that it must have some connection with the external atmosphere; that no fire can exist without air; and, therefore, no fire exists at twenty or twenty-five miles beneath the surface-earth, if there is such a crust or envelope over it as our geologists have maintained, because no air could get through the gradually heating and expanding rock. I

Fire only reconstructive.

hope, also, that I may now be allowed to answer the question—What has fire done upon the earth? Fire has only reconstructed and destroyed. Nothing has found an origin in fire. Fire itself is an effect, and not a cause; it is in the atmosphere, it is in

Its labour.

the flint in the earth, it is in the water—in each it is a thing by itself, unseen or unfelt; certain conditions bring it into active existence, but it cannot be traced in either element as a matter of course. Yet it is here, there, and everywhere; it has built up Cotopaxi to the height of 18,000 feet; Teneriffe has been shot up by its labours from an unknown depth beneath the sea to 12,000 feet above it; Etna is heaped up with lava, ashes, and scoriæ some 11,000 feet; Iceland has grown into a great island under its influence; and Vesuvius has grown to a height of 3,731 feet from a reconstruction of earthy matter by fire. Well may man in his narrow chamber have thought that all this, and

Magnitude of work leading to error, but the law of nature plain.

much more, was far beyond the labour of local forces, and naturally has he put it down to one great internal and eternal cause; but as he steps out of that chamber, and sees nature through the uncounted ages always at work upon the one great labour I have endeavoured to describe, I do not

think that many will hesitate to accept my interpretation of volcanic phenomena. I have left but little to imagination; I have borrowed many of my facts from well-known authors; and whatever I have said of their interpretations, I have done nothing to invalidate their facts. I have outraged no law of nature in my sketch, but have followed the plain course of production and reproduction; my ideas have been formed by an intimate acquaintance with wild nature for more than forty years; I have seen it under more phases than most men, and I have invariably found her true to herself. There is much in nature that man cannot see, and much that he cannot understand; its condition changes as the figures in a kaleidoscope, and we all see these conditions with different eyes; our varied gifts are a part of nature's changes, and the more we employ them the more we may become convinced of their littleness; but under this humiliating condition we find that our poor reason is a gift from our Creator; that without His aid we should be powerless to argue without bias on the construction of the earth, of which we are, and into which we shall in our turn depart; but we know that all this is as much under God's

Varied reason sees in varied aspects, but the Spirit of God moved on the waters and created earth.

control as His Spirit was when it moved upon the face of the waters to create this earth.

Conclusion leading to other phenomena.

So far, I have nearly concluded the subject as presented to the reader in my first chapter; but in working it up I find another question so intimately connected with it, and so inseparable from the water formation, as it has been presented to my eyes, that I now propose to devote a chapter to the consideration of a few phenomena which have been supposed by geologists to be connected with a glacial period in the earth.

CHAPTER IX.

BOULDERS AND GLACIAL DRIFT.

THE more I read the more I become convinced that some of our great geologists have mistaken, and continue to mistake, the character of many natural phenomena on the surface of the earth; and I propose to show in this chapter that drifts, boulders, furrows, and other formations which have been attributed to a glacial period, are even now in course of making in regions where no ice exists, and that in consequence their evidence in reference to a supposed cold epoch is not to be relied on.

Under the heading, Boulder Clay, or Glacial Drift, at p. 290, "Geology Advanced Text-book," Page tells us that there is no formation more perplexing, or whose origin is involved in greater obscurity, than this "glacial drift" or "boulder clay." If

these deposits, and other natural formations dependent on the same causes, are brought in as evidence of a glacial period, there can be no doubt of the perplexity they would cause to the head that endeavoured to prove their connection; but when taken in their simple character, as ordinary results of natural causes, which have for ever been, and will, as long as earth and water exist, continue to be at work, their obscurity vanishes at once. The subject has, however, become so involved in arguments that I find it necessary to clear up many specious theories before explaining the system as I have seen it at work; so that by the confutation of these theories nothing will be left to prevent the acceptation of that, which I believe to be the true interpretation of an ordinary work of nature.

"Geology Advanced Text-Book," pp. 290-1.

The definition of the subject, as given by Page, is "Water-worn blocks or boulders of all sizes, from a pound to several tons in weight, detached or in masses, but more frequently enclosed in the clays, without regard to gravity or any other law of arrangement;" "As if brought together by some unusual and extraordinary operation of water;" "Districts are thickly strewn with boulders, which rest on the bare rock formations without any

accompanying clays or sands; and at times only a single gigantic boulder, or a few perched blocks, will be found reposing on some height, as evidence of the drift formation;" "On examining the surfaces of many of these boulders we find scratches and groovings, as if they had been rubbed forcibly over each other in one direction; and what is still more curious, the surfaces of the rocks on which the boulder clay reposes are all less or more smoothed and marked with bold linear scratches and furrows, as if the boulders had been forcibly carried forward, and had scratched and grooved them during the passage;" "These ruts and groovings all tend in one direction."

Although Page thinks that these arrangements of earthy matter may have been brought about by the action of water, he prefers making them act as evidence in favour of the great glacial theory; for at page 292, he writes—"We can conceive of no current sufficiently powerful to transport boulder blocks of many tons in weight over hill and dale for hundreds of miles;" "of no sedimentary conditions that would permit boulders and clays to be huddled up in one indiscriminate mass." Having thus wandered from the true path, he has recourse

to "arctic lands with glaciers and avalanches to wear and waste, and arctic seas with icebergs and ice-floes to transport the eroded material." These floes and bergs, "laden with boulders and gravel from other regions, passed over these latitudes, and dropped their boulders on our submerged lands;" and in passing on they "ground their way through the firths, smoothing and grooving the surfaces of opposing rocks, and dropping as they melted away their burdens of silt and boulders on the deep sea bottom." So confident is Page of the truth of this arrangement, that he tells us, if the laws of nature had been looked to more carefully, "the drift formation, with all its complicated phenomena, had long been an established fact of the science, instead of a medley of perverted observations, respecting which scarcely two geologists entertain the same opinion."

Doubtful interpretations.

This was printed ten years ago, but we are told by Professor Agassiz, in his "Journey in Brazil" (p. 398), that "the existence of a glacial period, however much derided when first announced, is now a recognised fact." Having thus announced his belief, he goes to South America for the express purpose of finding evidence to support

his recognised fact; and in this determination he has, as I shall presently show, given doubtful interpretations to natural phenomena.

I know of no more certain way of forming a medley of opinion on natural subjects than the endeavour to force them into one groove. If there is any hitch or obstruction in that groove, then every detail of nature which is required to support it is out of order; there can be no hitch or obstruction in the great laws, and no one knows that better than Mr. Agassiz, for he says, "If the geological winter existed at all, it must have been cosmic;" to which I readily consent, and add, if it did not exist in Europe or in Scotland, it did not exist on the tropical line of the Amazons; and I propose now to show that boulders, clays, smoothings, and groovings, or scratches on rocks, are no evidence in favour of a glacial epoch, which is supposed to have covered this earth with caps of ice and snow, north and south, "moving towards the equator" (p. 403). Cause of errors.

The first thing I have to deal with is the boulder, a small or a large "water-worn rock," worked into a rounded shape, sometimes found "grooved and scratched" (Page), "sometimes without marks" Boulders.

(Agassiz), "not a trace of furrows or striæ," which are generally thought to be "glacial inscriptions." Thus, then, the same force is supposed to have marked the boulders in Scotland, and to have left them unmarked in the valley of the Amazon!

How made. No glacier or avalanche ever made a boulder; it is made, as Page tells us, by "long-continued action" of water. Glaciers may, in passing downwards, tear off fragments from the hard rock, or the softer bank of the mountain side; but these remain on the surface of the glacier, or may become covered with snow; but once upon the ice, they are not liable to erosion. In process of time every rock fragment gathered by the glacier in its descent comes to the melting point; and rolling or subsiding, it helps to form the moraine. In this situation it undergoes the action of water. This action by no means depends on the glacier, as a rule; the ice only occasionally takes the place of water, and every stream from every hill-side has a better chance of boulder-making than a glacial valley.

By water.

For three years I was in Khandesh (India), on the banks of the Taptee river, a powerful stream running between banks from 70 to over 100 yards wide, and rising occasionally some forty feet in a

night. There were here plenty of opportunities of watching the fracture of rocks, and the gradual formation of the fragments into boulders, with the attendant phenomena of a polished and furrowed bed, and scratched or grooved boulders. Our stonemasons use water and sand in dividing or smoothing stones. The art is a copy from nature. The rocky bed of a river has in it irregularities of all sizes. Sand and gravel getting into these, are perpetually acted on by the force of the stream *in one direction.* The result is a scratch or a groove dependent on time and the capacity of the irregularity or hole from which the work first commenced. In the absence of any hard nodules or other substances in the straight line, it is continued through the entire face of the rock till it ends in the broken edge of the ever-wearing stream. The scratches on the large boulders are made in a different, and in a much more scientific manner. While liable to the strong action of the current, any marks which may have been made upon them are likely to be eroded; and it is only when, by accident of heavy floods, they are lodged in the more feeble confines of the stream that the scratchings commence and remain.

Examples.

Formation of scratches.

As these scratchings are intimately connected with the accumulation of clay, sand, and gravel, I will bring the whole system together.

When a mass of rock is lodged in an eddy, or on the confines of a current, it follows that the same force which brought the mass there is capable of moving lighter materials. All such materials immediately take advantage of the large mass, and settle under its protection. As the force of a current is perpetually changing, it sometimes deposits large and sometimes small stones and boulders in the same locality. Every stone or boulder becomes then a hiding-place, and Page's little fancy of "nests and patches of gravel," and crowded accumulations of boulder stones, all without regard to gravity, "or any other law of arrangement," is at once pictured to the mind. By this simple and every-day process any boulder which happens to be thus deposited is, as it were, propped up by the materials which gather below it, and in this condition is liable to receive the scratches or furrows which have erroneously been ascribed to ice action.

Deposit of unstratified material by water.

No water current retains its same level for ever: river currents change several times in the year, but

it is only when the streams run low or the water sinks to its ordinary level that the scratching action takes place.

Whenever the water washes along the side of a fixed or moveable rock, boulder, or stone, that side of the stone being exposed to sunshine, there is a small breadth of the stone perpetually liable to heat and moisture. It may be called the "water line." On this line stones of almost any hardness are inclined to crack, or peel, or exfoliate. As soon as an entrance, however small, is effected, the run of the water wears upon the line; and according to the time the stone is exposed to the action, according to the erosive powers of the water, or according to the resistance of the stone, so deep and so extensive will be the furrow or the scratch. By this inevitable law one boulder may have on its surface many scratches: if they are parallel, they show that the boulder had not moved, but that the level of the water had changed; if, as is frequently the case, the scratches are found running across one another, or at different angles, it follows that the boulder had moved without subjecting itself to a general erosion or fracture. These small movements are in the case of strong

Scratches, how made.

floods, of constant occurrence, so that large masses are sometimes turned slightly or completely over, and yet never move far from the site of their original settlement. It seems to have increased the perplexity of this subject by finding some boulders scratched and some without marks. If the scratches had been formed by passing ice, this perplexity would have been natural; but as some of my boulders are completely covered by the summer stream, as some of them are quite out of water at that time of the year, when alone scratches are made, there can be no possible cause of perplexity or doubt as to the origin of boulder-marks, or no marks; while boulders intermixed with sand, clay, or gravel nests, having no scratches to impute to ice, are indisputable proofs of their current formation.

Proofs.

If these scratched boulders had been deposited by ice in that condition, I find another insuperable objection to the theory. If the water was deep enough to float an iceberg, and if its current was strong enough to move it, any stones dropping from the ice would be liable to the action of the water, the scratches on them would have been liable to erasure, to say nothing of the probable

Ice theory wrong.

destruction of the whole mass. Again, if all the accompaniments to these boulders had come on floe or berg, and gone to the bottom simultaneously with the breaking up of the ice, the deposits could not have been "so utterly without regard to gravity or the laws of arrangement" as Page tells us they are; for the great boulder would have dropped in one place, the smaller would have gone on to another, while the gravel, clay, sands—would all have been deposited by the carefully discriminating water. It would not even have neglected the flatter fragments, but would have rubbed them along the gritty bottom till they were worn away or left with a multitude of little scratches upon them as exhibited to us in No. 81, Cabinet C, of the Jermyn-street Geological Museum.

One of the most perplexing points met with by geologists is the supposed deficiency of water power to convey great blocks of stone over hill and dale "for hundreds of miles." By the system I am presenting to the reader there is no room for doubt on the subject. No rocks or stones were moved over hill and dale for the very simple reason that there were no hills or dales there at

Perplexing effects of ice theory are results of water action.

the time the boulders were deposited. We must date the period of their deposit to the time when there were no valleys there, when water covered the whole locality, and when, as is the case with all water, it left some hard and some soft deposits. It was while the waters were gradually retiring from these positions that the boulders were made and deposited where we find them. They were the fragments of unknown high and hard places, their foundations are our present hills, while the denudating currents of those times as they slowly retired etched out the lines for future rainfalls to wear away the valleys into their present condition.

Failure of ice evidence.

As I have stated, Mr. Agassiz went to Brazil in hopes of finding evidence of a glacial system. He was not long in doing so, for he came upon clay, boulders, pebbles, quartz, sand, gravel—all unstratified; and tells us (p. 403, "Journey in Brazil") that they leave "no doubt in the mind of anyone familiar with similar facts observed in other parts of the world that this is one of the many forms of drift connected with glacial action." He supposes this action to "arise from an immense field of ice extending over the whole north," so as to "initiate a pressure radiating in every direction."

In short, we are called upon to imagine this sunny world that we live in as clothed in two caps of ice, "northern and southern, moving towards the equator." Under these circumstances, the valley of the Amazon must have been a trysting place, and these ice-caps must have felt some melting moments hereabouts; they could not have moved unless they had thawed; and Agassiz tells us (p. 426) that the ice "must have ploughed the valley over and over again, grinding all the materials into a fine powder or reducing them to small pebbles." As I read this I exclaimed, "Never! no ice ever made pebbles;" but I was soon relieved of my doubt, for at p. 428 Mr. Agassiz tells us that "the first effect of the thawing process must have been to separate the glacier from its foundation, raising it from immediate contact with the valley bottom, and thus giving room for the accumulation of a certain amount of water beneath." So, then, if the ice did not touch the bottom of the valley, it did not plough it up, or grind the materials into powder, or make pebbles; but all this was done, as is doing every day, by the simple force of water; so that for all the evidence produced I cannot discover that the

valley of the Amazons has ever been colder than it is now.

It appears that this cold epoch is supposed to have been in the Pleistocene period, the first geological group of the tertiary system, and therefore of a comparative recent occurrence. Such an ice-bound system as that contemplated by Agassiz must necessarily have had some effect upon animal and vegetable life; but, says Page (p. 343), "Geology cannot point its finger to a single break in the great evolution of vitality any more than it can point to a moment's cessation in the physical operations of nature from the deposition of the first-formed strata to the layer of mud left along shore by the last receding tide;" and, as if this is not sufficient, he tells us "the whole of our groups and systems are merely successive stages in one great system of cosmos;" and then we find the same "gigantic coniferous and filicoid plants are found alike in the coalfields of Britain, America, Melville Island, and Australia;" and at p. 204 we find that these plants required a temperature for their growth "more humid and equable than tropical." Thus, then, by our own natural perceptions, and by the science of geology, we are led to

Evidence against the Ice system.

believe that ever since the carboniferous system of the Paleozoic period, millions of years ago, everything in nature has gone on without a break in it. We find the same products in the tropics now as we detect in our old coalfields; and the late deep-sea dredgings by H.M.S. "Porcupine" show us that the same animalculæ still exist at the bottom of the ocean as built up our old chalk hills.

With all this evidence of sameness, continuity, and equable temperature, I should be justified in saying that no glacial period ever existed upon this earth to the extent asserted; but as I only glean my information from such works as come accidentally before me, there may be other evidence on the subject of which I am ignorant, so that I am unable to go so far; but this I will say, that while icebergs or floes may convey boulders, gravel, sand, and other materials from one place to another, neither these materials nor the ice on which they rested had anything to do with smoothing or grooving the rock beds, or with scratching boulders; and I do assert that all these actions have been, and now are, performed by water.

Water performs the whole.

The formations and phenomena here alluded to are so familiar to me in their daily, their perpetual

examples; I have watched them so frequently in operation; their causes and effects fit so beautifully and accurately, while their whole history is so natural and complete, that while I read the interpretations which others have put upon them, I endeavour to discover the causes of their errors.

Conclusion. Every here and there I am in hopes that their arguments will lead to the truth; but, like many of our pursuits in this world, they have gone back to the preconceived glacial period. I do not say that such a time never existed. Poets have fancied strange things of heaven and earth:—

> "Let earth unbalanced from her orbit fly—
> Planets and suns run lawless through the sky."

But we have no evidence on these points, while some of the evidence of a glacial period has failed. I will therefore conclude this subject with a hope that those who are interested in it will correct me if I can be proved wrong in what I have advanced; while, if I am right, the great jury of the public will be able to say whether the doubts I have thrown upon some of the supposed evidence of a glacial epoch are sufficient to overthrow the whole theory.

NOTE.—Though the text was concluded in last year, I am every day falling in with matter confirmatory of my system of earth formation; and the following extract from the *Morning Post* of Feb. 8th, 1870, will give an extra force to what I have said on the formation of the valley of the Amazons:—"Neither Bates, Wallace, or Agassiz found any marine fossil on the banks of the great river. It remained for Professor Orton to discover at this little Peruvian village of Pebas a fossiliferous bed interculated between the variegated clays so peculiar to the Amazons crowded with marine tertiary shells." Amongst these was the "nevitina pupa." "It is a singular fact," adds Mr. Norton, "that the nevitina is now living in the West Indian waters, and the species found at Pebas retains its peculiar markings; so that we have some ground for the supposition that not many years ago there was a connection between the Carribbean Sea and the Upper Amazon; in other words, that Guiana has only very lately ceased to be an island." Here we have a complete confirmation of what I say—that the seas gradually retired as the great water-shed from the Andes filled up the space with the *débris* of the earth, so that beneath all this deposit marine remains are sure to be found, even on the upper slopes of the mountains; but, the *Morning Post* continues: "In a subsequent communication to the author, Mr. Darwin writes, 'Your discovery of marine shells high up the Amazon possesses extreme interest, not only in itself, but as one more striking instance how rash it is to assert that any deposit is not a marine formation because it does not contain fossils. As for myself, I never believed for a moment in Agassiz' idea of the origin of the Amazonian formation.'" When I think of the time in which this great Amazonion region has been forming, and look at the vast amount of water now running through it, I feel no difficulty in comprehending that the original tail of the Andes has furnished, by means of its broken-up material, its vegetable and animal growth, the whole of the surface deposits which overlie the great ocean foundations of Bolivia, Brazil, Peru, Columbia, and Guiana.

CHAPTER X.

In commencing this little work I felt myself almost overwhelmed with the mass of printed paper before me; but finding that, in the ordinary course of human strength and life, I could not possibly hope to digest the entire subject, I took up such parts only as, in my opinion, would serve to elucidate the simple argument on my mind—*Water or Fire?* Having written so far, I sent my pages to be printed; but the subtle genius of man compelling me still to read on, I find volumes in plenty opening out the secrets of their souls. In these I find certain theories which, differing slightly from those I have remarked on, require some little attention from me lest it might be said that, not having opposed, I had consented to them. I do

Other theories.

not mean by this that I am now going to discuss the subject over again. I have touched upon all the main points for which I could find time; and as I write only for the sake of truth, I take up but little space; but having written so far, my imperfect work would be more so if I did not notice a few matters in contemporary writing which have lately come before me.

In 1866 a manual of geology, by the Rev. Samuel Haughton, M.D., F.R.S., had passed through two editions, and given to thousands of the reading world the substance he had lectured on to the listeners. This gentleman thought "that Laplace's nebular hypothesis is the nearest approach that we are capable of making to an astronomical history of the origin of our globe;" but not quite content with the speculation as presented, he made further inquiries, and found that, according to Durocher, "we have evidence that the first and second layers of the globe are composed of totally different materials." The outer layer was called the "acid magma," corresponding to granite; the inner layer was called the "basic magma," corresponding with trap rocks and green stones. Mr. Haughton says there can be very

Laplace's "Nebula," p. 2.

Durocher, p. 3.

Magmas.

Page 4. Page 7. little doubt of the general correctness of Durocher's theory, which, as a chemical geologist, he adopts; and tells us that, "as the globe cooled, we know that fissures formed in it, evidence of which fissures still remains in our mountain chains and metallic lodes. These fissures themselves are filled from below with a class of compounds totally different from the acid or basic magma." I have explained how fissures are frequently made in rocks, but Mr. Haughton does not tell us why these compounds came up in supercession of his two great materials. He thinks, however, that, because sulphur and salts are found in these fissures, they must have come from below, and that inside the two magmas there is "a layer composed of these sulphur salts." According to this theory we have, at some twenty or twenty-five miles beneath our feet, one granitic layer, one basic, and below these the salt.

Fissures filled from layers, p. 8.

Ejected by compression and gases, p. 34.

We are not told whether this salt rises in a fused state or a vapoury; but on turning to Appendix A, translation from Durocher, I find "the upper portion of the fused mass rises through the openings by virtue of the compression it experiences from the adjacent masses and the expansive power of

elastic gases. Thus are produced the great eruptions that bring to light the granite magma." The basic magma is supposed to be disturbed by this process, and some of it is drawn "into the hollows and crevices of the terrestrial crust." Nothing is here said about the salts, but by what follows it would never do for this soluble and perishable material to be liable to the same pressure as its more indestructible superiors; for "these siliceous masses giving origin to chains of mountains or hills of rounded contour," it would never have done to make them of salt, and that is left below till required to fill up some little fissure. In its neglected state this salt layer is allowed to lend a back to the granite and basic magmas; or, in other words, being below these heavy materials, it offers so much resistance with its untenacious bulk that when a pressure comes upon the siliceous materials above it, they jump up through twenty or twenty-five miles of varied strata, through which no fissure is given, instead of performing the very natural and ordinary routine of subsiding out of the way of the pressure into the soft sulphur salts.

Mountains raised from magmas through the earth, p. 35.

We are told a little further on, "the formation of mountain chains cannot be attributed to earth-

Without earthquakes

quakes," but "the formation of chains of mountains, or of volcanos, is, in fact, the consequence of ruptures effected in the entire thickness of the terrestrial crust." According to Durocher, that is some twenty-five miles deep; but Mr. Haughton does not quite understand why this limit is assigned, and thinks that "2,500 appear to be equally entitled to consideration"—a remark in which I quite concur; but why a rupture through all that thickness of earth should not produce an earthquake I do not understand, unless it is that, as our present quakes do not produce mountains, it would not have done to say that quakes produced them at any other time.

In searching for a reason why these vast masses should rise through imaginary fissures to form mountain ranges, I come on a sentence in the translation from Durocher which throws a ray of light upon the whole system :—"Whatever be the reason, it is certain that the basic rocks, whose eruption took place during the primary geological periods, were formed merely by accident, as compared with the immense development of the silicious and felspathic masses." If we once allow accident to take a place in nature, we are relieved

Ejections accidental, page 35.

from all responsibility as to the interpretation we may place upon any occurrence out of the common; but the change, in the mode of supposed eruption assigned thus unceremoniously to accident, is the result of a very ordinary rule of law. The granites were first deposited from the settling chaos, and then, as materials grew on the dry land, and were washed into and worn by the waves, they settled down as the eddies and the whirls required, and thus during a certain geological period these materials were left in "veins or masses of moderate dimensions;" but as these earthy materials were mixed up with triturated portions of the all-pervading granite, the chemical composition of the latter is retained in the former. The class of geologists I am alluding to appear to have had no thought on the subject of mountain formation except the eruption:—"The earth's surface cooled, it contracted upon the liquid interior, by the re-action of which (being incompressible) it was ultimately rent into certain fissures, elevated above the general surface, through which flowed the molten glass that afterwards, when metamorphosed by the action of water, became granite, and subsequently the trappean lavas." As a great many of our mountain

Accidents not to be accepted.

Rule of law, pp. 35-6.

Theory glass.

Conversion to granite, p. 146.

Granite made by water, p. 41.

ranges are composed chiefly of granite, I will examine for a few lines Mr. Haughton's origin of granite. He tells us that he has in his text adopted the theory of Durocher; yet he "does not believe that any trace of these primitive magmas is now to be found." He tells us that the granites of Finland, Sweden, Norway, Scotland, and Donegal are the "oldest granites in Europe, and are proved to have been of aqueous origin." We find a curious corroboration of this in *Nature* of 31st March, 1870, where Mr. C. Spence Bate says: "In one of these granite slabs my companion pointed out to me the presence of a large water-worn boulder of sand-stone." This was evidence "that water was present in its liquid state when it was rubbed into its present form. It also demonstrates that the pebble was in existence as a hard rock before the granite was formed." As then the sandstone was a water formation, so was the granite. Without entering upon the never-ending arguments of geologists and chemists for or against a universal water formation of granite, I put the simple question to either party—If granite was made by fire, from what substance was it made? Fire may convert, but it cannot make; therefore

granite was not made by fire, and the difficulty of geologists as to the penetration into other stones or rocks is much easier got over on the water than on the fire system. We have granite running into sandstone and limestone. No one supposes that either of these were ever in a molten state, but the granite must have been in a state of liquidity to run into its neighbour. If this were hard, I deny that the granite, in whatever state of liquidity it might have been, could ever have found an entrance as it has done. If, however, the other materials were alongside of the granite mixture, and all in a state of water liquidity, the very union that we see would take place, the little eddies would wash lines of granite mixture into the sand or lime, and the ingredients of one would mix up with the ingredients of the other whenever their edges came in contact, if their formation was progressing simultaneously. Similar effects can be seen any day in the banks between two streams. They vary in strength every hour, and as each brings down particles of a varied nature, these banks become a very beautiful and a most intricate study; so that the mixture of rocks which has hitherto been attributed to fire can be

Geological difficulty explained.

Mixture of rocks.

Example.

If any by water, why not all?

effected by other agency, and if there are any granites of admitted aqueous origin, I claim the same for all, and ask Mr. Haughton—If his granite mountains are made by molten matter pressed up through the earth, or ejected through it by gases, how are his slate, marble, limestone, or sandstone mountains formed? On the Himalayas, the Andes, the Alps, and many others, we have these water deposits; and Mr. Haughton thinks that the fact of their being there only proves "that they have been raised above the surface of the sea, and depressed below it many times during the history of the earth." As that history is not yet written, I beg to record my disbelief in the theory of such depressions and upheavals, which must, if occurring anywhere, have taken place from Vancouver's Island to Tierra del Fuego; from Vancouver's Island, all across America, Europe, and Asia, to Behring's Straits; from Cape Verd to Guardafui, and in divers offshoots from all those lines of mountain ranges. The aspect of the regions forbids me, for a moment, accepting this theory, and I call upon every little sand ripple on the sea shore, with crag and tail, upon every sand hill on a windy coast, to explain to these

Theory, p. 134.

Disbelieved for a reason.

geologists how the mountain ranges of the world were made.

Having so far opposed Mr. Haughton's mountain theory, I will borrow a few words of fact in support of my earthquake system. "If," he says, "we now examine earthquakes, we shall recognise in them characters totally different from those of volcanic phenomena. They give rise to no effect, either calorific or chemical." Having a "property of linear and almost definite extension, directly opposed to the radiating and circumscribed action of volcanos, shows that the two classes of phenomena have a different seat;" and this coincides exactly with what I have before said. Here, again, we have a gentleman of genius and scientific attainment who, close upon the brink of the truth, refuses to see it, because he was intent on "the effects which are experienced from the transmission of disturbances imparted to the inner surface of this crust at its contact with the incandescent liquid layer," to which we will not again return; but if in my earthquake chapter I have broken down the bank upon which Mr. Haughton hesitated, I shall in a measure have repaid him the instruction I have gleaned from his book.

Haughton's earthquake charactes vary from volcanos, so do mine, p. 38.

Why he refuses to see the truth, p. 39.

Caves.

I have casually mentioned caves, and referred the reader to a former pamphlet of mine on this subject; but as the *Popular Science Review* returns to the errors of Cuvier and Buckland (October number, 1869), in a paper on Kent's Hole, by Mr. Dawkins, I propose showing in a few words how near this gentleman approaches the system of cave formation which I have published. He says: "The ceiling at the time of its deposition must have been supported by a layer of cave-earth." Of course it was supported by something, because, as Mr. Dawkins allows, "it would indeed be as impossible for a solid calcareous sheet to be formed in mid air as it would be for a sheet of ice to be formed without resting on the water." He is quite conversant with the water formation, and allows that the working causes "must have been aqueous;" yet he sticks to the old routine, and tells us that the hyena lived in the cave, and destroyed the original owners of the bones found there. Now, the cave-earth which Mr. Dawkins relies on for a support was not *in situ* when the cave was formed. Nothing that has been discovered over the lowest stalagmite floor was there; all of that has been brought in since the cave was

Dawkins' theory explained.

formed. The support of the calcareous sheet, on its original formation, was that matter which is now found beneath the lowest stalagmite floor, and I quote part of the system from my "New Pages of Natural History:" "The walls and roof of this cave are formed of limestone; this limestone was once in solution; while in solution it was deposited on a mould; this mould was formed of any material collected by the stream; streams in flood wash down all such matter as they find on the face of the earth: this matter is gathered by eddies and whirls in large quantities; banks and heaps are made." Some of these become fixtures. Upon these the ordinary deposits of water are left, which, eventually growing, are deserted by the water. The eddy or whirl-gathered heap is now the nucleus of a limestone mass: its component parts are, some comparatively, perishable, and some indestructible, when hermetically sealed by a sheet of lime. This sheet of lime embraces every portion of the heap, and is a perfect cast of its strange mould, so that, excepting the stalactites, the interior of the cave represents the exact shape of the mound gathered by the water. No sooner was a lime formation completed, than the ordinary

lime-dripping began; this, at first settling on the nucleus, formed a sheet between it and the water deposit, but as the perishable portions of the nucleus subsided from natural decay, this stalagmite sheet sunk with it, its own weight separating it from the roof of the growing cave. As the subsidence was irregular, these fragments broke off in bits, and hence the broken stalagmite flooring alluded to by Mr. Dawkins. This material has in many instances percolated entirely through the nucleus mass, even into the very bones it found below, and is a convincing proof that the bones were there before the lime, and consequently formed the nucleus for the lime to rest upon, as required by Mr. Dawkins. This is a very simple history, without a flaw or a doubt about it. It is very common; and man, digging up the floor, finds beneath his feet an incident of unknown times, "when a water-flood hurried off the beasts of the land," and gathered them, with unconsumed bones, and all the *débris* around, on its curling tides into these mausoleums, where the hermetical sealing has preserved them, till man proves his ignorance of nature's works by saying that the hyena placed them there. Geology and science

may be puzzled as to time and the supposed period of the cave formations, but there is no other interpretation than mine which can by any possibility account for the cave or the preservation of the bones. For further information I refer the curious to the pamphlet just quoted.

I have asked a question in my chapter on "Boulders and Glacial Drift," which I now find was replied to about the same time as I was writing, by Mr. Alfred M. Wallace, in *Nature* of 16th and 18th November, 1869. I inquire when the supposed glacial period existed; he replies—"It does not appear, therefore, that any estimates of time, founded on actual basis of observed change in a known period, require us to assume more than 80,000 years since the close of the glacial epoch, while the measurement of the existing rate of denudation renders it almost certain that it was less rather than more;" and referring to the elaborate calculations of Mr. Croll, he remarks: "So that we may conclude, if eccentricity has anything to do with it, that the last glacial period came to an end not less than 70,000 years ago." These cold periods are supposed to have visited us occasionally ever since the form-

Glacial times.

Wallace.

Croll.

ation of the earth, and Mr. Wallace gives us a calculation of time between the lower Miocene and Cambrian eras of 132,000,000 years. He tells us that "the Rhone basin is being lowered at the rate of a foot in a thousand years;" and

Inundation.

"denudation in Wales and Scotland must probably have gone on as rapidly as the average rate of the Rhone valley; and 80,000 years will therefore imply eighty feet of average denudation over the whole surface of the country." If we take ordinary and glacial seasons as occupying, at intervals of 80,000 years each, the 132,000,000 years just alluded to, without considering the time which has elapsed from the Cambrian to present period, we have 825 ice, and 825 temperate seasons of 80,000 years each, which will give us 66,000,000 years of denudation, equal to a lowering of 66,000 feet; but from whence was this to come? Taking Ben

Measurements on time or glacial epochs are wrong.

Nevis at 4,380 feet at present, it must have been 61,620 feet higher; while Dawalegeri, now 27,000 feet high, must have been 39,000 feet higher than it is now. I believe on such heights there never could have been any melting epoch, and consequently no denudation; so that either the denudation is erroneous, time is wrongly calculated, or there *were no* glacial epochs; and Earth has gone on in

its steady routine of growth and denudation, of which no two seasons, no two localities, can give similar data, and all in spite of those who aspire to traduce its regularity. While I was throwing this light upon Mr. Wallace's calculations, Mr. W. Boyd Dawkins, in *Nature*, No. 20, objects to them on more scientific grounds, and tells us that "the problem is hedged in by innumerable difficulties, which cannot be overcome in the present state of science." *Nature*, of 24th February, 1870, tells us that there is no trace of glacial action on the Pacific slope. I do not think that Nature would be true to herself if any so-called glacial traces were found upon the crag side of mountains. There may be exceptions, but the run of water is generally too rapid to admit of the formations and marks which have, as I believe, been erroneously attributed to glacial seasons. I believe, therefore, that my interpretations on this point, and all their results, may be considered as unimpeachable.

Nature. Mr. Dawkins objects to the same calculations.

Nature finds no glacial signs on Pacific slope.

My interpretation true.

I have quoted Mr. David Forbes to show that there is, as I have said, a difference in all lava ejections, proving that they do come from varied sources of matter; but that gentleman has, I find, expressed elsewhere another opinion. To make

Lava.

the subject clear to my reader, I place his two sentences together:—

D. Forbes.

Athenæum, 13th February, 1869, No. 2,155, p. 249: "A comparison of the numerous published analyses of lava by Bunsen, and other eminent chemists, will show the analyses quoted by Mr. Malet to be quite exceptional in composition, and indicate that he is probably not aware that the lavas emitted by active volcanos are of two very different characters," thus agreeing with Durocher; but in the *Popular Science Review*, of April, 1869, No. 31, he writes: "The hypothesis that the earth was essentially solid necessitated that the phenomena of volcanos should be explained upon the supposition that they had their sources in numerous small local basins scattered over the globe—a view which seems altogether incompatible with the results of chemical and mineralogical investigation, which proves that the ejected products are identical in constitution, even if taken from the vents which are most distant from one another."

Two theories.

One is wrong.

It is quite possible that scientific men may be able to reconcile *identity of constitution* with *difference of character;* but Mr. Forbes was good

enough to tell me in the above-quoted *Athenæum*, one lava is "strikingly analogous to the old granites in chemical composition," and the other "nearly, if not quite, identical with the basalts." I therefore look to the analyses quoted in the *Athenæum* by Mr. Forbes, and find—

	Dublin. Granite. Haughton.	Iceland. Lava. Bunsen.	Etna. Lava. Fuchs.	Vesuvius. Lava. Silvester.
Lime	1·84	2·49	10·38	18

There is no occasion to go further; but I find no identity anywhere. I now turn to Table II., p. 20, Haughton's "Geology:"—

	Basalt.	Mean.	Granite.	Mean.
Lime {	7·0 14·0	10·2	11 1·5	0·7

Of course I allow that similarity of constitution between the lavas, which one bit of dirt has to another, but I deny identity of constitution between any two lavas from any two emissions, the same as I deny identity of face between any two men. Ejections may come from the same rock, but the composition of that may not be everywhere identical, and the character of the

No iden[tity] of lavas

molten rock may be altered in many ways—by the force of heat, the distance of ejection, and the manner of cooling, but still it is lava, and of granitic or basaltic origin. Mr. Forbes, however, mystifies the subject in a more unintelligible way, for while he writes to the *Popular Science Review*, rejecting the local basins, he refers me, in *Athenæum* of April 3rd, 1869, to "Vesuvius," by Professor Phillips, who, as I have already shown, advocates the theory of local basins. I do not understand why he referred me to this, if he did not believe in it; the main point can, however, be reached without the necessity of deciphering the enigmas of man. I have, as I hope and trust, read Nature truly, and explained my readings in unambiguous language; and while I complain of the contradictions, and even of the terms as adopted by scientific men, I will allow that the subject could not be otherwise than cloudy, starting as they do from a mythical point—an imaginary, inherent, internal heat, supposed by themselves to be somewhere between us and 2,500 miles beneath our feet.

[Confusion of science inseparable from its point of view.]

I have now to wind up the subject, leaving many points untouched, which I have not thought necessary to place before the jury of mankind.

CHAPTER XI.

CONCLUSION.

HAVING thus discussed current theories in reference to certain phenomena on the surface, and beneath the surface of the earth, and having opposed these theories with such arguments as I have found available, I may say with confidence that I have outraged nature in no single point. I have seen in warm climates nature performing those labours, which have been assigned to a glacial period, and consequently, if there is no other proof of an icy epoch, there is no evidence of the existence of such a period in the regions accused of enjoying it. If our geologists are wrong in one point, they may be so in others. I have proved by their own words a variety of interpretations on phenomena which could bear but one, and I have proved the impossi-

bility of some of the igneous phenomena being brought about from causes assigned by the wisest of our philosophers.

We can no more hope to trace the true cause of any phenomena which may be presented to us on earth without going to the fountain-head than we could hope to put a watch together without knowing the use of each part. In putting my interpretations forward, I have endeavoured to trace the causes of each phenomenon to the well-known fountain-head; so that, while my systems are supported by the great law of nature, I have no hesitation in saying that the theories I oppose have no sure source to depend upon, geologists themselves only claiming the evidence of *a general belief;* so that the condition of the entire hypothesis is similar to the game of "follow the leader." There are in the cases under consideration many leaders, and all appear to have followers. There is nothing so attractive to man as the mysterious, and those who explain the mysteries make devotees of those whose minds are fitted to the explanation; but there are many of these followers, and many of these leaders, who would accept other interpretations if opportunities are offered for probing

the subject to the bottom. Either they have not found this chance, or, by a misdirection, natural effects have been traced to non-existing sources, or, as I have frequently pointed out, the true mark has been missed by using foregone conclusions. In every-day life we find the same thing. The chief necessary of life (money) leads many (millions I may say) to trust to their leader, and accept a foregone conclusion. There is a visible profit in doing so; but the bubble bursts, and the falsity of the conclusion is exposed. In the same way some of those who believe in an inherent internal heat of the earth may now reject that belief with greater facility than they can throw off their connection with a fraudulent banker.

However imperfect my details may be, and however briefly I have touched upon the great wonders of nature, I feel that I have said enough to convince some minds that my foundations are good and solid. I have re-opened an old subject, and brought forward to its support some points which have not, to my knowledge, been previously discussed. I have been able to do this by a long and familiar acquaintance with the destructive force of floods, the ordinary working of rivers, the effects of the

percolation of rain, the gradual denudation of the surface, and the hidden erosion of interior earth by water causes. While for many years I have seen and studied these forces at work, contemporary writers have been intent upon tracing the phenomena alluded to into one great cause. They have been intent upon this point; but with all their great industry, and all their natural acuteness, they have failed to fit their machinery together. On the contrary, I have only devoted such time as I could afford from my never-ending duties in life to the wonderful study of nature; and as there is a perpetual hope in this study that one may reach the fountain-head upon every point which is successively presented to the eye, so I now hope that the evidence which my poor gifts enable me to place before my fellow-creatures may lead them to a true comprehension of such phenomena as I have here ventured to discuss.

Looking thus hopefully on the intelligent jury of the world, I may suggest that there may be slips or hitches in my arguments; but though such may militate against the point in connection with them, they will not, I believe, affect the whole, which resolves itself into a few words:—

The Spirit of God moved upon the face of the waters and created this earth ;—

Fire has, in its place, and in its turn, contributed to a recreation.

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